HANDBOOK OF FLOWER POLLINATION

BASED UPON

HERMANN MÜLLER'S WORK
'THE FERTILISATION OF
FLOWERS BY INSECTS'

BY

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OBSERVATIONS ON FLOWER POLLINATION MADE IN
EUROPE AND THE ARCTIC REGIONS
ON SPECIES BELONGING TO THE NATURAL ORDERS

RANUNCULACEAE TO STYLIDIEAE

WITH 210 FIGURES IN THE TEXT AND A PORTRAIT OF
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OBSERVATIONS ON FLOWER POLLINATION

IN

EUROPE AND THE ARCTIC REGIONS

[The abbreviations made use of in the bibliographical references are—where possible—those of the 'International Catalogue of Scientific Literature.' The following are employed in the statements regarding the flower-visits of insects:—nect-lkg., nectar-licking; skg., sucking; po-cltg., pollen-collecting; po-dvg., pollen-devouring; freq., frequent. When there is no special reference to locality, Knuth's observations are to be regarded as having been made in Schleswig-Holstein (more especially near Kiel), those of Hermann Müller in the neighbourhood of Lippstadt (Westphalia), those of Buddeberg in Nassau, and those of Borgstette in Tecklenburg.]

ANGIOSPERMAE

CLASS I. DICOTYLEDONES

I. ORDER *RANUNCULACEAE* JUSS.

LITERATURE.—Herm. Müller, 'Fertilisation.,' pp. 69–89; Knuth, 'Bl. u. Insek. a. d. nordfr. Ins.,' pp. 16–17, 'Grundriss d. Blütenbiol.,' pp. 15–17.

The Ranunculaceae are characterized by a great variety of flower arrangements, such as is met with in but few other orders. The conspicuousness of the flowers is sometimes due to the corolla (Ranunculus, Batrachium, Adonis), sometimes to the calyx (Clematis, Hepatica, Pulsatilla, Anemone, Caltha, Trollius, Helleborus, Eranthis, Aconitum), sometimes to both (Aquilegia, Delphinium), and sometimes even to the stamens (Thalictrum). The colour of the flowers is frequently white, greenish, or yellow (Anemone, Batrachium, Ranunculus, Myosurus, Caltha, Trollius, Helleborus, Eranthis, Actaea), more rarely red, blue, or violet (Pulsatilla, Atragene, Hepatica, Adonis, Aquilegia, Delphinium, Aconitum, Paeonia). The modes of secretion and concealment of nectar are quite as varied as the devices by which conspicuousness is brought about. Nectar may be secreted by the sepals (some peonies), by the stamens (Pulsatilla), or by the carpels (Caltha), but usually by the petals, either at their bases (Batrachium, Ranunculus, Myosurus), or in specialized nectaries resulting from their metamorphosis (Trollius, Helleborus, Eranthis, Aquilegia, Aconitum, Nigella). Comparison of some of the nectaries in the order (Fig. 1) shows a gradual transition from the perfectly simple nectar-pit of Ranunculus to the complex apparatus of Aconitum. In Trollius the petal is much reduced and possesses an elongated nectar-groove above its base, in Helleborus the expanded

limb has already completely disappeared, so that only a nectar-cup remains. In Aquilegia there is a similarly formed organ, but much larger, inverted, and curved round at the tip, serving not only to secrete and conceal nectar, but also to attract insects, being therefore brightly coloured. The nectary of Aconitum is shaped much like that of Aquilegia, but it is smaller and provided with a long stalk—the claw of the original petal—which serves to conceal nectar more deeply. The remarkable nectary of Nigella is not connected by any intermediate gradations with the preceding.

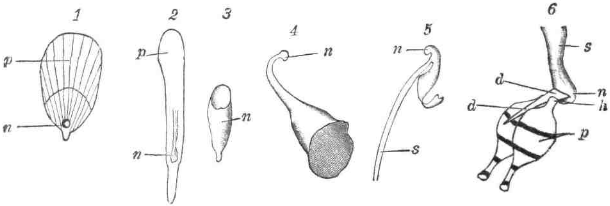

FIG 1. *Nectaries of some Ranunculaceae.* (Enlarged. From nature.)

1. *Ranunculus sceleratus, L.*
2. *Trollius europaeus, L.*
3. *Helleborus niger, L.*
4. *Aquilegia vulgaris, L.*
5. *Aconitum Napellus, L.*
6. *Nigella arvensis, L.*

n, nectary. *p*, limb. *s*, stalk. *d*, cover. *h*, protuberance.

In not a few Ranunculaceae no nectar is secreted (Clematis, Thalictrum, Anemone, Hepatica). These provide pollen for their insect-guests, as a reward for their work in securing cross-pollination. There are therefore some Ranunculaceae in almost all the flower-classes, as follows.—

Po or **An**: Clematis (most species), Thalictrum, Anemone, Hepatica, Adonis, Actaea;

E: Myosurus, some sp. of Ranunculus and Batrachium;

EC: Ranunculus, Batrachium, Caltha, Eranthis, Isopyrum, Cimicifuga;

C: Pulsatilla, Trollius, Helleborus;

H: Aquilegia, Delphinium, Aconitum, Atragene, Nigella.

Species belonging to the flower-classes **Po, An, EC,** and **C,** are homogamous or slightly protandrous, more rarely protogynous. In these—owing to the relative position and time of maturation of stamens and carpels—automatic self-pollination is possible in the later stages of flowering should insect-visits have failed. In species belonging to class **H**—on the other hand—self-pollination is largely prevented by marked protandrous dichogamy, and the visits of bees are often indispensable for fertilization.

The visitors and pollinators belong to all insect-orders. The white, yellowish-green, and yellow pollen flowers, and the similarly coloured flowers with readily accessible nectar, are visited chiefly by short-tongued insects, especially flies and beetles, more rarely by Hymenoptera, still more rarely by Lepidoptera. The blue pollen flower Hepatica—on the other hand—is chiefly visited and pollinated by

pollen-seeking bees. Trollius—a yellow flower with concealed nectar—receives visits from Hymenoptera, Diptera, and Coleoptera, in about equal numbers, while the violet Pulsatilla is pollinated almost exclusively by bees. Aquilegia, Delphinium, and Aconitum, are characteristic humble-bee flowers; Nigella and Atragene are equally characteristic bee flowers.

1. **Clematis** L.

Mostly pollen flowers with petaloid sepals, by which conspicuousness is secured.

1. **C. Vitalba** L. (Herm. Müller, 'Weit. Beob.,' I, p. 312; Schulz, 'Beiträge,' I, p. 1; Kirchner, 'Flora v. Stuttgart,' p. 258; Loew, 'Blütenbiol. Floristik,' p. 175; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Notizen.')—Protogynous pollen flowers. The flowers are arranged in dense cymes, carried high into the air by the climbing stem, so that the white reflexed sepals, and the white stamens, make the plant conspicuous from a distance. The hawthorn-like odour of the flowers (due to trimethylamine) serves as a further means of attraction. The flowers are slightly protogynous (according to Schulz occasional ones may be homogamous), and at the time of flowering the numerous erect undehisced stamens are rather lower than the stigmas, which are already mature. The filaments now elongate, and bend outwards as the anthers dehisce. Since the outer stamens are the first to ripen, self-pollination is at first rendered difficult. But as the stigmas continue receptive till the innermost stamens are ripe, it becomes easy in the final stage of flowering.

The visitors and pollinators are pollen-collecting bees and pollen-devouring flies. These necessarily effect cross-pollination when they pass from one blossom to another, alighting in the middle of the flower upon the rather prominent stigmas. It is very difficult to observe their actions because of the height of the plant.

VISITORS.—The following have been observed by Buddeberg (Budd.) in Nassau, by Hermann Müller (H. M.) in Westphalia, and by myself (Kn.) in Holstein.—**A. Diptera.** (*a*) *Muscidae*: 1. Musca domestica *L.* (Kn.); 2. Sarcophaga carnaria *L.* (Kn.); 3. Scatophaga stercoraria *L.* (Kn.); all po-dvg. (*b*) *Syrphidae*: 4. Eristalis nemorum *L.* (Kn.); 5. E. tenax *L.* (Kn.); 6. Rhingia rostrata *L.* (Kn.); 7. Syrphus balteatus *Deg.* ♂ (Kn.); 8. S. ribesii *L.* ♀ (Kn.); all po-dvg. **B. Hymenoptera.** (*a*) *Apidae*: 9. Apis mellifica *L.* (Kn., H. M., very freq. in Thuringia); 10. Andrena albicans *Müll.* (Kn.); 11. Halictus calceatus *Scop.* (Kn.); 12. H. nitidiusculus *K.* ♀ (Budd.); all po-cltg. (*b*) *Vespidae*: 13. Odynerus parietum *L.* ♂ (Budd.).

Loew observed the following in Steiermark ('Beiträge,' p. 46).—**A. Diptera.** *Syrphidae*: 1. Syrphus lunulatus *Mg.*, po-dvg. (?). **B. Hymenoptera.** *Apidae*: 2. Halictus malachurus *K.* ♀, po-dvg.

MacLeod observed in the Pyrenees one humble-bee, and 5 Diptera, as visitors ('Pyreneenbl.,' p. 389).

2. **C. recta** *L.* (Herm. Müller, 'Fertilisation,' p. 69; Schulz, 'Beiträge,' I, p. 1; Beyer, 'D. spont. Bewegungen. d. Staubgefässe u. Stempel'; Knuth, 'Bloemenbiol. Bijdragen'; Kirchner, 'Flora von Stuttgart,' pp. 258–9.)

While the last species generally exhibits slight protogyny, C. recta is feebly protandrous. The white flowers are arranged in terminal paniculate cymes. When they open, the stigmas are not yet fully mature, and are covered by the stamens which closely invest them. The outermost of these at once bend outwards and their

anthers dehisce, so that the flowers are in the first or male condition, in which they yield pollen to insects, but are incapable of retaining on their stigmas any that may be brought. Automatic self-pollination is equally impossible at this stage. The outward curving and dehiscing of the stamens progresses centripetally, but before the innermost ones have dehisced the stigmas have matured, and are liable to be touched by such pollen-covered insects as may alight in the middle of the flower. Bees collecting the abundant pollen almost invariably alight in the centre—according to Hermann Müller's observations—while pollen-devouring flies are very erratic in their mode of settling and, creeping about the flowers, may effect either cross- or self-pollination. Failing insect-visits, self-pollination may easily be effected by contact of the stigmas—which remain receptive—with the innermost stamens.

VISITORS.—Hermann Müller observed the following.—**A. Coleoptera.** *Scarabaeidae*: 1. Trichius fasciatus *L.*, devouring the anthers. **B. Diptera.** (*a*) *Muscidae*: 2. Prosena siberita *F.*; (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. E. sepulcralis *L.*; 5. Helophilus floreus *L.*; 6. Syrphus pyrastri *L.*; 7. Syritta pipiens *L.*; 8. Xylota ignava *Pz.*; 9. X. lenta *Mg.*; all po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 10. Andrena albicans *Müll.* ♀; 11. A. gwynana *K.* ♀; 12. Apis mellifica *L.* ☿; 13. Bombus terrester *L.* ♀; 14. Halictus sexnotatus *K.* ♀; 15. Osmia rufa *L.* ♀; 16. Prosopis signata *Pz.* ♀; all po-cltg. (*b*) *Sphegidae*: 17. Gorytes mystaceus *L.*, perhaps only hunting flies; 18. Oxybelus uniglumis *L.*, po-dvg. (*c*) *Vespidae*: 19. Odynerus parietum *L.* ♀, as 17. Handlirsch mentions as a visitor the fossorial wasp Gorytes mystaceus *L.*

On garden plants I saw only one pollen-devouring hover-fly, Eristalis tenax *L.*

3. **C. Viticella** L. (Knuth, 'Bloemenbiol. Bijdragen') is nectarless like the preceding, despite its very large dark-violet, blue, or red pollen flowers. I have only once observed the honey-bee collecting pollen on plants that were grown in Kiel for the purpose of covering a bower. No observations are available from the Mediterranean region, which is the home of this form.

4. **C. balearica** Rich. (= C. cirrhosa *L.*) is a nectar flower indigenous in the Mediterranean region. The outer stamens—according to Delpino—are modified into spoon-shaped nectaries. The same observer mentions Bombus and Xylocopa as visitors of this species.

5. **C. integrifolia** L. is also a nectar flower. According to Delpino ('Applicazione d. teoria Darwiniana,' p. 8) the inner stamens secrete nectar. The pendulous flowers—according to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 349–50)—are protogynous for a short time, and therefore adapted for cross-pollination at the beginning of flowering. The stamens lie close together so as to form a short tube, in the base of which the numerous still immature stigmas are situated, while the outer anthers have already dehisced, thus furthering cross-pollination. The anthers of the inner stamens gradually dehisce, but, owing to the pendulous position of the flower, would be unable to effect self-pollination were there not an elongation of the carpels during the last two days of flowering, so that if pollination has not been effected by insects, the stigmas—spreading out to some extent—receive some of the pollen still adhering to the stamens.

6. **C. angustifolia** Jacq.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—**Hymenoptera.** *Apidae*: Bombus terrester *L.* ☿, po-cltg.

2. Atragene L.

Homogamous bee flowers. The large sepals serve for attraction; the small petals are converted into nectaries.

7. **A. alpina** L. (=Clematis alpina *Miller*). (Herm. Müller, 'Alpenblumen,' pp. 124–5; Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 349–50; Schulz, 'Beiträge,' p. 1.)—A characteristic bee flower. According to Hermann Müller, this plant is homogamous in the Alps, but self-pollination is quite excluded, so that fertilization is entirely due to visitors, which are chiefly Apidae (see Fig. 2).

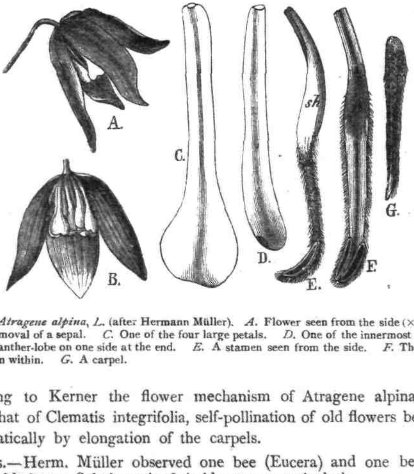

FIG. 2. *Atragene alpina*, *L.* (after Hermann Müller). *A.* Flower seen from the side (× 2/3). *B.* The same after removal of a sepal. *C.* One of the four large petals. *D.* One of the innermost small petals, with a small anther-lobe on one side at the end. *E.* A stamen seen from the side. *F.* The same seen obliquely from within. *G.* A carpel.

According to Kerner the flower mechanism of Atragene alpina completely agrees with that of Clematis integrifolia, self-pollination of old flowers being brought about automatically by elongation of the carpels.

VISITORS.—Herm. Müller observed one bee (Eucera) and one beetle; Ricca observed humble-bees; Schulz noticed Apidae more particularly.

3. Thalictrum L.

Pollen flowers in which the stamens serve for attraction, or anemophilous flowers occasionally visited by insects. Kerner observed opening and closing of the anthers as a result of variations in the humidity of the air.

8. **T. aquilegifolium** L. (Herm. Müller, 'Fertilisation,' p. 70, 'Alpenblumen,' p. 115; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel': Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Schulz, 'Beiträge,' II, pp. 1–2; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Knuth, 'Bloemenbiol. Bijdragen.')—This tall plant is conspicuous from a distance, owing to the many stiff club-shaped stamens of pale violet colour, which radiate from the centre of the numerous

crowded flowers. In young flowers the stigmas—mature according to Müller, partly immature according to Schulz and Ricca—are covered by the unripe inner stamens, being thus shielded from contact with insect visitors, which, in this first condition of the flower, get dusted with pollen as they creep about collecting or devouring this kind of flower-food. The inner stamens subsequently ripen and spread out, so that insects alighting in the middle of the flower must necessarily effect cross-pollination if they come from other flowers of the same species. Should insect-visits fail, self-pollination takes place automatically, for the stigmas are situated in the line of fall of pollen from the inner anthers.

It is also possible that the light and but slightly adhesive pollen may be carried by the wind, but—as Schulz remarks—anemophily cannot often obtain, for the closely crowded stamens keep pollen from the stigmas.

Visitors.—According to the observations of Hermann Müller (H. M.), and myself (Kn.), these are pollen-collecting bees or pollen-devouring flies and beetles.—**A. Coleoptera.** (*a*) *Nitidulidae*: 1. Meligethes (Kn.). (*b*) *Scarabaeidae*: 2. Trichius fasciatus *L.*, devouring the anthers (H. M.). **B. Diptera.** *Syrphidae*: 3. Eristalis arbustorum *L.* (H. M.); 4. E. nemorum *L.* (H. M.); 5. E. pertinax *Scop.* (Kn.); 6. E. sepulcralis *L.* (H. M.); 7. E. tenax *L.* (Kn., H. M.); 8. Rhingia rostrata *L.* (H. M.); 9. Syrphus balteatus *Deg.* (Kn.); all po-dvg. **C. Hymenoptera.** *Apidae*: 10. Apis mellifica *L.*, po-cltg. (Kn., H. M.); 11. Halictus cylindricus *F.* ♀ (Kn.); 12. H. sexnotatus *K.* ♀, po-cltg. (H. M.); 13. Prosopis signata *Pz.* ♂ ♀, po-cltg. (H. M.).

In the Alps Herm. Müller also saw 4 flies, 3 beetles, 3 Hymenoptera.

Loew observed the following in the Berlin Botanic Garden.—**A. Coleoptera.** *Scarabaeidae*: 1. Cetonia aurata *L.*, devouring the anthers. **B. Diptera.** *Syrphidae*: 2. Syritta pipiens *L.*, po-dvg. **C. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.*, po-cltg.

9. **T. alpinum** L.—A pollen flower. The stamens projecting far out of the pendulous flowers indicate that the plant is anemophilous. According to Lindman the stigmas mature before the stamens, but remain in a receptive condition during the dehiscence of the anthers. According to Ekstam, the flowers are protogynous-homogamous in Nova Zemlia. According to Kerner, the stigmas of this species are at first concealed under the sepals: but after the sepals have fallen away they may be geitonogamously pollinated by neighbouring flowers. The same is true of—

10. **T. flavum** L. (Herm. Müller, 'Fertilisation,' p. 70; MacLeod, 'Bot. Jaarb. Dodonaea,' Ghent, vi, 1894; Schulz, 'Beiträge,' II, p. 2.)—According to Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1896) the flowers are slightly protogynous to homogamous. The pollen is yellow, polyhedral, smooth, about 25–30 μ in diameter.

Visitors.—I observed the following in the gardens at Kiel.—Apis mellifica *L.* ☿, and Bombus lapidarius *L.*; po-cltg. Hermann Müller also observed the former in the Lippe meadows, near Lippstadt, as well as a number of pollen-devouring Diptera:—(*a*) *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. tenax *L.*; 4. E. sepulcralis *L.*; 5. Syritta pipiens *L.* (*b*) *Muscidae*: 6. Pollenia vespillo *F.*

11. **T. minus** L. (Herm. Müller, 'Weit. Beob.,' I, pp. 312–13; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' II, p. 2; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen.')—The filaments—which are narrowed at the base—project loosely from the nectarless flowers, and are moved by every breath of wind. The plant is therefore to be regarded as anemophilous. Owing to the sulphur-yellow colour of the stamens, however, the flowers are very conspicuous, so that insects now

and then visit them. The plant may consequently be said to fluctuate between anemophily and entomophily, for which reason I term its blossoms 'wind flowers.' Visitors effect cross- and self-pollination with equal ease. There being well-marked protogyny, crossing is frequently secured, even when the pollen is carried by the wind. While Herm. Müller found the flowers to be strongly protogynous in Thuringia, they are—according to Schulz—quite homogamous, or but feebly protogynous in South Tyrol.

According to Kerner, the stigmas are at first hidden under the sepals. Geitonogamy becomes possible when these are shed.

VISITORS.—On the island of Rügen I observed the following.—**Diptera**. *Syrphidae*: Eristalis tenax *L.* po-dvg. Buddeberg (in Nassau) noticed Syrphus sp., po-dvg. Hermann Müller (in Thuringia) observed a beetle (Oedemera virescens *L.*), po-dvg. Schulz noticed various flies, bees, and beetles. In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 1), one of the Muscidae was observed on the flowers.

12. **T. glaucophyllum** Wend.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—**Coleoptera**. *Scarabaeidae*: Cetonia aurata *L.*, devouring the anthers.

4. Hepatica Dillenius.

Pollen flowers. The calyx-like involucre—situated close to the flower—serves for attraction. Sometimes gynomonoecious and gynodioecious.

13. **H. triloba** Gilibert (= Anemone Hepatica *L.*). (Sprengel, 'Entd. Geh.,' p. 291; Herm. Müller, 'Weit. Beob.,' I, p. 313; Schulz, 'Beiträge,' II, p. 178; Calloni, Justs bot. Jahresber., Leipzig, xiii (1885), 1887, p. 751; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 194, 213; Schröter, Arch. Sci. Phys., Genève, xiv, 1885, p. 283; Knuth, 'Bloemenbiol. Bijdragen.')—The involucre—composed of several bracts—is so near the open flower expanded in the sunshine, that it looks like a calyx, and its dark-blue colour is very conspicuous among the fallen yellow leaves of beeches and hazels. According to Kerner, the involucral bracts double in length during the eight days of blooming, thus making the flower still more conspicuous. Müller states that the outer stamens develop simultaneously with the carpels, from which they curve away, so that insects' visits at this stage may result in cross-pollination. The inner stamens mature later, and self-pollination must then result automatically. According to Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896, p. 1) the flowers are protogynous. The connective of the two white anther-lobes—which dehisce laterally—is white or violet. The stamens project beyond the stigmas, so that autogamy is ultimately unavoidable. According to Schulz and Schröter, gynomonoecious and gynodioecious plants occur sporadically.

VISITORS.—These have been observed chiefly by Hermann Müller (H. M.) and myself (Kn.). They are mostly pollen-devouring and pollen-collecting insects, which creep about upon the open flowers and may lead to either cross- or self-pollination. They are as follows.—**A. Coleoptera**. *Staphylinidae*: 1. Staphylinus? (Sprengel at Spandau). **B. Diptera**. *Syrphidae*: 2. Eristalis tenax *L.*, po-dvg. (Kn., H. M.). **C. Hymenoptera**. *Apidae*: 3. Apis mellifica *L.* ☿, (Kn., freq. in Kiel Garden, po-cltg.; H. M., very freq. in Westphalia); 4. Osmia rufa *L.* ♀ (H. M.),

possibly skg. nectar. **D. Lepidoptera.** *Rhopalocera*: 5. Rhodocera rhamni *L.* (H. M.), settling for a considerable time and probing various parts of the base of the flowers with the tip of its extended proboscis; 6. Vanessa urticae *L.* (Kn.), possibly skg. nectar.

14. **H. angulosa** DC.—

Loew observed on the flowers in the Botanic Garden at Berlin.—**Hymenoptera.** *Apidae*: Apis mellifica *L.* ☿, po-cltg.

5. Pulsatilla Tourn.

Protogynous flowers with concealed honey (rarely pollen flowers). Nectar secreted by external vestigial stamens. The large brightly-coloured sepals serve for attraction. In addition to the hermaphrodite flowers, some species (P. vulgaris, vernalis, pratensis, and montana) possess others which are andromonoecious and androdioecious, gynomonoecious, and gynodioecious.

15. **P. vulgaris** Miller (= Anemone Pulsatilla *L.*). (Sprengel, 'Entd. Geh.,' p. 290; Herm. Müller, 'Weit. Beob.,' I, pp. 313–14; Schulz, 'Beiträge,' I, p. 2; Knuth, 'Bl. u. Insek. a. d. nordfr. Ins.,' pp. 17, 147, 'Bloemenbiol. Bijdragen.')—

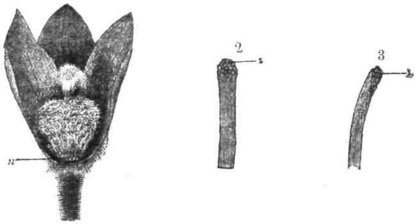

FIG. 3. *Pulsatilla vulgaris, L.* (from nature). 1. Flower from which the two anterior sepals have been removed. *n*, nectaries. The numerous stigmas project beyond the anthers. 2. Stigma (*s*) of a central carpel. 3. Stigma (*s*) of a marginal carpel. (2 and 3 highly magnified.)

The large blue-violet sepals form an effective means of attraction to the erect flowers. In the first flowering-stage the stigmas are already receptive, and they remain in this condition for the next two to four days, while the extremely numerous stamens are dehiscing. Nectar—as in the case of the following species—is secreted by the outermost stamens, which are converted into stalked capitate structures. As the stigmas project far above the longest stamens (see Fig. 3, 1), pollen-collecting and nectar-sucking insects first come into contact with them, and effect cross-pollination if they have already visited a flower of the same species.

VISITORS.—Hermann Müller (H. M.) and myself (Kn.) have chiefly observed nectar-sucking and pollen-collecting bees as pollinators, and ants as nectar-thieves.—**A. Hymenoptera.** (*a*) *Apidae*: 1. Apis mellifica *L.* ☿, skg. and po-cltg. (Kn., freq. at Kiel; H.M., Thuringia); 2. Bombus lapidarius *L.* ♀, skg. (Kn., Kiel; H. M., Thuringia); 3. B. terrester *L.* ♀, skg., holding on by stamens and peduncles during the process, and working round the flower to empty the nectaries in succession (Kn.,

Kiel, freq.; H. M., Thuringia); 4. B. hortorum *L.* ♀ (Kn.), as the last. H. M. also observed in Thuringia: 5. Andrena gwynana *K.* ♂ skg.; 6. Halictus cylindricus, *F.* ♀, po-cltg., freq.; 7. H. morio *F.* ♀, po-cltg. (*b*) *Formicidae* (all nectar-thieves); 8. Lasius alienus *Foerst.* ☿; 9. Leptothorax interruptus *Schenck* ☿; 10. Myrmica levinodis *Nyl.* ☿; 11. M. ruginodis *Nyl.* ☿; 12. M. scabrinodis *Nyl.* ☿; 13. Tapinoma erraticum *Latr.* ☿. **B. Coleoptera.** (*a*) *Nitidulidae*: 14. Meligethes, nect-lkg. (*b*) *Meloidae*: 15. Larvae of Meloë. **C. Hemiptera.** 16. Aphanus vulgaris *Schill.* **D. Thysanoptera.** 17. Thrips, very freq.

Schenk observed in Nassau, Osmia rufa *L.* ♀.

16. P. pratensis Miller. (Sprengel, 'Entd. Geh.,' p. 289; Francke, 'Einige Beitr. zur Kennt. d. Bestäubungseinricht. d. Pfl.'; Loew, 'Blütenbiol. Floristik,' p. 390; Schulz, 'Beiträge,' I, p. 3; Knuth, 'Bloemenbiol. Bijdragen.')—The dark-violet sepals of the large pendulous flowers are arranged in the form of a bell, so that they constitute a roof by which the stamens and carpels are protected from rain. The flower mechanism agrees with that of the preceding species. Protogyny excludes autogamy. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes the flowers found in the neighbourhood of Ruppin as first protogynous and subsequently homogamous. Pollen of a shining white; the grains are about 37 μ in diameter.

Visitors.—Loew (L.) and myself (Kn.) have so far only observed bees as pollinators. On alighting, these first touch the stigmas—which project beyond the stamens—and then holding on to the crowded stamens, collect pollen or suck nectar.—**Hymenoptera.** *Apidae*: 1. Apis mellifica *L.* ☿, and 2. Bombus hortorum *L.* ♀ (Kn., Kiel), skg. and po-cltg.; 3. Osmia bicolor *Schr.* ♀ (L., Brandenburg meadow), po-cltg.

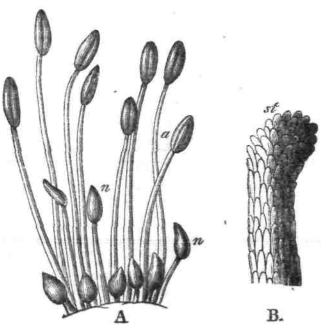

FIG. 4. *Pulsatilla vernalis, L.* (after Herm. Müller). *A.* A few of the external stamens modified to form nectaries (*n*), and behind them a few fully developed stamens (*a*). *B.* Apex of style with stigma (*st*); highly magnified.

17. P. vernalis Miller. (Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Herm. Müller, 'Alpenblumen,' pp. 125–7; Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Schulz, 'Beiträge,' II, pp. 2–4.)—The sepals—which spread out in the sunshine—are white on the inner side, bright violet to rose-red externally. They serve to attract insects. The flower mechanism deviates in some points from that of the two preceding species: protogyny is usually much less marked, and there may even be almost homogamous flowers. Further, according to Beyer, dehiscence of the anthers progresses outwards and inwards from a central zone. Schulz observed flowers which were quite nectarless. Lastly, Kerner noted, in addition to cross-pollinated hermaphrodite flowers with short stamens, others with long stamens, in which self-pollination automatically took place on the closing of the flower. Plants that Lindman observed

on the Dovrefjeld were similarly capable of autocarpy as a result of automatic self-pollination.

Visitors.—Lindman observed a fly visiting the flowers on the Dovrefjeld. In the Alps, Herman Müller observed 6 **Hymenoptera**, 12 **Diptera**, 4 **Lepidoptera**, and 2 **Coleoptera**.

18. **P. patens** Miller.—According to Kerner, this essentially agrees with P. vulgaris in the arrangements of its large violet-blue protogynous flowers.

Visitor.—I observed in the Botanic Garden at Kiel, Bombus hortorum *L.*, skg. and po-cltg.

19. **P. montana** Hampe, and 20. **P. transsilvanica** Schur, agree with P. vulgaris as regards their flower mechanism. Kerner mentions that old flowers of P. transsilvanica may pollinate themselves by maturation of the inner stamens.

21. **P. alpina** Delarbre (= Anemone alpina *L.*). (Herm. Müller, 'Alpenblumen,' pp. 127–8; Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' II, pp. 4–7.)—This species, with its sulphur-yellow variety (Anemone sulphurea *L.*), bears protogynous pollen flowers. The variety predominates in the Riesengebirge and Central Alps of the Tyrol, while the ordinary form characterizes the Eastern Limestone Alps. According to Kerner, this plant—like P. vernalis—bears hermaphrodite flowers of two kinds, respectively possessing few short stamens, and numerous long ones. As before, the former form is cross-fertilized, while the latter is autogamous. Hermann Müller found some androdioecious flowers, in addition to hermaphrodite ones, and Schulz found the still rarer andromonoecious flowers. In the Riesengebirge only 3–5 % are male flowers, in the Alps 80–95 %. They are smaller than the hermaphrodite ones.

Visitors.—Hermann Müller observed in the Alps 6 bees, 12 flies, and 2 beetles. Frey in Graubünden observed one species of Lepidoptera, Lypusa maurella *S. V.* Dalla Torre and Schletterer in the Tyrol observed Bombus alticola *Kriechb.* ♀ and ♂, tolerably freq.

6. Anemone Tourn.

Monogamous, slightly protogynous, or slightly protandrous pollen flowers. Petals wanting. Insects attracted by the sepals, which are usually white or yellow, more rarely violet, red, or blue. Individual species (A. Richardsoni *Hooker*—in Greenland) are also probably wind-pollinated (Warming).

22. **A. sylvestris** L. (Herm. Müller, 'Weit. Beob.' I, p. 314; Schulz, 'Beiträge,' II, p. 7; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II.)—In the milk-white homogamous, or slightly protogynous, or slightly protandrous flowers, the inner stamens bend together above the stigmas, so that self-pollination must occur automatically. The flowers when expanded in the sunshine attain a diameter of 70 mm., and consequently attract many insects, which, as they creep about, may effect either self- or cross-pollination.

Visitors.—Hermann Müller observed the following in his garden at Lippstadt.—**A. Coleoptera.** (*a*) *Cerambycidae*: 1. Grammoptera ruficornis *F.*, devouring the anthers. (*b*) *Dermestidae*: 2. Byturus fumatus *F.*, po-dvg. (*c*) *Malacodermata:*

3. Dasytes flavipes *F.*; 4. Malachius bipustulatus *F.*, devouring the anthers. (*d*) *Mordellidae*: 5. Anaspis rufilabris *Gyll.*, po-dvg. (*e*) *Scarabaeidae*: 6. Phyllopertha horticola *L.*, gnawing the flower. **B. Diptera.** (*a*) *Bibionidae*: 7. Bibio hortulanus *L.*, getting nothing. (*b*) *Empidae*: 8. Rhamphomyia sp.: 9. Tachydromia connexa *Mg.* (*c*) *Muscidae*: 10. Anthomyia sp., po-dvg.; 11. Calliphora vomitoria *L.*; 12. Chlorops hypostigma *Mg.* (*d*) *Syrphidae*: 13. Ascia podagrica *F.*; 14. Eristalis arbustorum *L.*, freq.; 15. E. nemorum *L.*, freq.; 16. E. tenax *L.*, freq.: 17. Helophilus floreus *L.*; 18. Pipiza funebris *Mg.*; 19. Rhingia rostrata *L.*; 20. Syritta pipiens *L.*, freq.; all hover-flies, eagerly po-dvg. **C. Hymenoptera.** *Apidae*: 21. Apis mellifica *L.*, po-cltg., freq., also skg.

Schulz also observed bees, flies, and—more rarely—beetles.

The flower mechanism agrees in the main with that of the next species.

23. **A. nemorosa** L. (Sprengel, 'Entd. Geh.,' p. 292; Hua, 'Anemone nemorosa *L.* var. anandra,' Bul. soc. bot., Paris, xxxvi, 1889; Herm. Müller, 'Fertilisation,' p. 72, 'Weit. Beob.,' I, p. 314; Kirchner, 'Flora v. Stuttgart,' p. 260: Webster, 'Change of colour in . . . Anemone nemorosa,' J. Bot., London, xxv, 1887; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894; Knuth, 'Bloemenbiol. Bijdragen.') — The flowers are considerably smaller than those of the last species, and insect-visits are consequently distinctly fewer in number.

The flowers are generally white, marked externally with reddish lines, seldom entirely red, and very rarely blue. The stamens at first project beyond the stigmas, so that the latter are protected from contact. Later on the stamens bend outwards, and as both they and the stigmas are now liable to be touched by visitors, either cross- or self-pollination may take place. Should insect-visits fail, the inclined position of the flower enables pollen to fall upon the stigma, thus ensuring autogamy. Hua observed flowers with reduced stamens.

In the pheasantry at Treskow, Warnstorf (Verh. bot. Ver., Berlin, xxxviii. 1896, p. 16) observed white flowers of two different sizes, 35 mm. and 20 mm. in diameter, respectively. The perianth leaves of the former are tinged with pale violet on their under-side, while those of the latter are yellowish green underneath. The peduncle of the large-flowered form attains a length of over 30 mm., but that of the small-flowered form is only about 25 mm. long. The flowers are all slightly protogynous: their inner and outer stamens are shorter than the middle ones, which are inclined over the gynoecium, so that self-pollination is easy. The anthers dehisce very irregularly. Pollen white, ellipsoidal to rounded tetrahedral, very finely tuberculated, about 37 μ long and 25 μ broad.

VISITORS.—Hermann Müller (H. M.) and myself (Kn.) have observed pollen-collecting bees, and pollen-devouring flies more particularly. — **A. Coleoptera.** (*a*) *Mordellidae*: 1. Anaspis frontalis *L.*, po-dvg. (H. M.); 2. Mordellistena pumila *Gyll.* (H. M.). (*b*) *Nitidulidae*: 3. Meligethes, po-dvg. (Kn., Kiel and Wiesbaden; H. M., numerous in the bases of the flowers). **B. Diptera.** (*a*) *Muscidae*: 4. Scatophaga merdaria *L.*, po-dvg. (Kn., Kiel and Wiesbaden; H. M.); 5. S. stercoraria *L.*, po-dvg. (as preceding). (*b*) *Syrphidae*: 6. Eristalis tenax *L.*, nect-skg., po-dvg. (as preceding). **C. Hymenoptera.** *Apidae*: 7. Andrena albicans *Mull.* ♂, po-dvg. (Kn., Wiesbaden; H. M.); 8. A. fulvicrus *K.* ♀, po-dvg. (H. M.); 9. A. parvula *K.* ♀, po-dvg. (H. M.); 10. Apis mellifica *L.* ☿ (Kn., Kiel and Wiesbaden; H. M.). H. M. observed that the honey-bee not only collects pollen, but also sucks, boring with its proboscis into the base of the flower, so as to obtain the sap which it requires for moistening the pollen. 11. Bombus terrester *L.* ♀, po-cltg. (H. M.);

12. Halictus cylindricus *F.* ♀, po-clg. (H. M.); 13. Osmia bicolor *Schr.* ♀, po-cltg. (H. M.). **D. Thysanoptera.** 14. Thrips (H. M.).

Alfken and Höppner (H.) observed in Bremen:—*Apidae*: 1. Andrena albicans *Mull.* ♀; 2. A. parvula *K.* (H.); 3. Apis mellifica *L.* ☿; 4. Bombus hortorum *L.* ☿; 5. B. pratorum *L.* ☿. All po-cltg.

MacLeod noticed in Flanders:—Apis, a sp. of Halictus, 4 Muscids, an Empid, a Lepidopterid, and 2 beetles.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 2), hover-flies, an Empid, and a Muscid were observed.

Burkill ('Fertlsn. of spring flowers, &c.') observed on the Yorkshire coast.—**A. Diptera.** (*a*) *Muscidae*: 1. Anthomyia sp., po-dvg.; 2. Scatophaga stercoraria, po-dvg. (*b*) *Syrphidae*: 3. Melanostoma quadrimaculata *Verall*, po-dvg. **B. Hemiptera.** 4. Anthocoris sp. **C. Hymenoptera.** *Apidae*: 5. Bombus terrester *L.* **D. Thysanoptera.** 6. Thrips sp.

24. **A. ranunculoides** L. (Herm. Müller, 'Weit. Beob.,' I, pp. 314–15; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bloemenbiol. Bijdragen.')—The mechanism of the golden-yellow flowers agrees with that of A. nemorosa. In the Treskow pheasantry Warnstorf observed two hermaphrodite forms, one bearing large flowers (30 mm. in diameter), the other small flowers (average diameter 18–20 mm.). On the other hand, in the park at Wustrau, he noted a form with very small, short-stalked flowers. Some of these possessed numerous green flower-leaves: the gynoecium was often quite vestigial, and the stamens reduced to small green sepaloid structures.

Visitors.—Hermann Müller (H. M.) and myself (Kn.) have observed the following.—**A. Diptera.** *Bombyliidae*: 1. Bombylius discolor *Mikan.*, vainly nect-skg. (H. M., Thuringia). **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿ (Kn., po-cltg.; H. M., po-cltg., and skg., Thuringia).

Loew observed in the Berlin Botanic Garden:—**Coleoptera.** *Dermestidae*: Anthrenus scrophulariae *L.*, po-dvg.

25. **A. narcissiflora** L. (Herm. Müller, 'Alpenblumen,' p. 128; Schulz, 'Beiträge,' I, p. 3.)—The flowers are protandrous: some of the stigmas of those examined by Schulz in the Riesengebirge were dark-brown, and functionless. The plants observed by Müller in the Alps were capable of automatic self-pollination.

Visitors.—Hermann Müller observed in the Alps 6 po-dvg. flies.

26. **A. baldensis** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II.)—The white periodically opening pollen flowers are partly protogynous and hermaphrodite, partly pseudo-hermaphrodite and staminate. The former appear in two forms, one possessing short stamens, and adapted for cross-pollination, the other with longer stamens and capable of automatic self-pollination.

27. **A. trifolia** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' II, p. 7.)—The white periodically opening blossoms are homogamous pollen flowers, in which automatic self-pollination is easy, since anthers and stigmas are closely approximated.

Visitors.—In the South Tyrol Schulz chiefly observed flies, also some bees and beetles. These may effect cross- as well as self-pollination.

28. A. apennina L. (Knuth, 'Blütenbiol. a. d. Ins. Capri.) — Slightly protogynous pollen flowers. When the violet blossoms have opened in the sunshine their diameter is 5 cm. They exhale a faint odour of cumarin. The numerous blue-black stamens are arranged in several whorls round the similarly coloured styles. The stigmas are mature shortly before the anthers dehisce, so that at this stage cross-pollination may result from insect-visits. The dehiscing anthers are so near the stigmas that automatic self-pollination must necessarily take place, and this seems to be the regular thing in Capri, where insect-visits are very rare, despite the very conspicuous character of the flowers.

VISITORS.—I only once saw a small fly (Muscidae) po-dvg.

29. A. japonica Sieb. et Zucc. (Knuth, 'Bloemenbiol. Bijdragen.') — This species—a native of Japan—is one of our ornamental garden plants. The diameter of the homogamous flowers is about 7 cm. The stamens at first lie close to the sepals, rendering self-pollination difficult, and favouring cross-pollination. Subsequently the stamens become erect, so that automatic self-pollination may result from contact of anthers and stigmas.

VISITORS.—I observed the following po-cltg. and po-dvg. insects.—**A. Diptera.** (*a*) *Muscidae*: 1. Musca domestica *L.*; 2. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 3. Eristalis tenax *L.*; 4. Syrphus ribesii *L.* **B. Hymenoptera.** *Apidae*: 5. Bombus terrester *L.* ☿. Of these, Eristalis and Bombus regularly alighted upon the middle of the flower, proceeding thence to the anthers, so that they almost always effected cross-pollination. The other visitors sometimes alighted in the middle of the flower, sometimes on the anthers, and consequently effected either cross- or self-pollination, as the case might be.

Loew observed in the Berlin Botanic Garden.—**A. Diptera.** *Syrphidae*: 1. Eristalis tenax *L.*, po-dvg.; 2. Syritta pipiens *L.*, po-dvg.; 3. Syrphus balteatus *Deg.*, po-dvg. on the stamens; 4. S. ribesii *L.*, as the last. **B. Lepidoptera.** *Rhopalocera*; 5. Pieris brassicae *L.*, repeatedly inserting the proboscis between the ovaries and apparently boring for sap with its tip. **C. Orthoptera.** 6. Forficula auricularia *L.*

Loew further observed—in the same place—the following upon the variety *purpurea*.—**A. Diptera.** *Syrphidae*: 1. Syrphus balteatus *Deg.*, po-dvg. on the stamens; 2. S. corollae *F.*, po-dvg. on the anthers. **B. Hymenoptera.** *Vespidae*: 3. Vespa germanica *F.*, settling and vainly trying to suck.

7. Adonis Dill.

Protogynous pollen flowers, opening and closing periodically. Their vivid red or yellow petals serve for attraction.

30. A. vernalis L. (Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Herm. Müller, 'Weit. Beob.,' I, p. 315; Knuth, 'Bloemenbiol. Bijdragen.') — The yellow flowers—according to Müller's account—expand in the sunshine to form a disk 40–70 mm. in diameter, visible from a distance, and turning towards the sun. When the flower opens, the numerous stigmas are already mature, while the still more numerous stamens are not yet fully developed and are directed outwards, so that in this condition cross-pollination may result from insect-visits. The stamens gradually erect themselves centripetally, and at the same time the anther-lobes on the sides of the broad connective dehisce laterally. When all the stamens are ripe they project a little above the

stigmas, so that either cross- or self-pollination can be effected with equal ease by insect-visits. At this later stage self-pollination is brought about automatically in dull weather, for the flower then closes and the stigmas come into contact with the pollen. Automatic self-pollination may also occur in sunshine, for as the flower turns towards the sun, pollen readily falls upon the stigmas.

VISITORS.—According to the observations of Hermann Müller (H. M.), in Thuringia, and myself (Kn.), in the garden at Kiel, the visitors are chiefly po-cltg. bees, and po-dvg. flies and beetles.—**A. Coleoptera.** (*a*) *Coccinellidae*: 1. Micraspis duodecimpunctata *L.* (H. M.), 4 in a flower, one licking the stigmas. (*b*) *Nitidulidae*: 2. Meligethes (Kn., H. M.), in very large numbers, po-dvg. **B. Diptera.** (*a*) *Muscidae*: 3. Scatophaga merdaria *L.* (H. M.), po-dvg. (*b*) *Syrphidae*: 4. Eristalis sp. (Kn.); 5. E. tenax *L.* (Kn.), both po-dvg. **C. Hemiptera.** 6. Lygaeus equestris *L.* (H. M.), very numerous, boring with their proboscis in the base of the flower. **D. Hymenoptera.** (*a*) *Apidae*: Andrena nitida *Fourcr.* ♂, po-cltg. (H. M.); 8. A. parvula *K.* ♀ (H. M.); 9. Apis mellifica *L.* ☿, freq. (Kn., H. M.); 10. Bombus terrester *L.* ♀, settling, but neither skg. nor po-cltg. (H. M.); 11. Halictus albipes *F.* ♀ (H. M.); 12. H. cylindricus *F.* ♀, freq. (H. M.); 13. H. morio *F.* ♀ (H. M.); (*b*) *Formicidae*: 14. Formica congerens *Nyl.* ☿ (H. M.), very freq., busying itself with anthers (po-dvg.?) and stigmas (skg. their moisture?). **E. Thysanoptera.** 15. Thrips (H. M.), not infrequent. In some flowers a spider was found lurking for prey.

Loew observed the following in the Berlin Botanic Garden.—**A. Coleoptera.** *Nitidulidae*: 1. Meligethes sp., po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp., po-dvg. (*b*) *Syrphidae*: 3. Melithreptus scriptus *L.*, po-dvg. **C. Hymenoptera.** *Apidae*: 4. Andrena nitida *Fourc.* ♀, po-cltg.

31. A. aestivalis L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Knuth, 'Bloemenbiol. Bijdragen.') — The red or (in the variety A. citrinus *Hoffman*, sometimes considered a distinct species) yellow petals spread out in the sunshine, attracting pollen-collecting bees and pollen-devouring flies. The flower mechanism agrees with that of the last species, but owing to the smaller size of the flower there are fewer insect visitors.

VISITORS.—I observed in the Garden at Kiel.—**A. Diptera.** *Syrphidae*: 1. Eristalis tenax *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, po-cltg.

32. A. autumnalis L. (Knuth, 'Bloemenbiol. Bijdragen.') — This agrees with the last species as regards its flower mechanism. According to Warnstorf (Abh. bot. Ver., Berlin, xxxviii, 1896), the flowers are homogamous and autogamous. When the pollen is ripe, the stamens lie close to the purple stigmas. The pollen is cinnamon-brown, and either irregularly elliptical with three longitudinal folds, or tetrahedral with spheroidal faces. The grains in the former case are 43 μ long and 25 μ broad, in the latter case 31 μ in diameter.

VISITORS.—I observed only Apis mellifica *L.* ☿, po-cltg.

8. Myosurus Dill.

Flowers homogamous or protandrous with exposed nectar, secreted at the bases of the small, inconspicuous, greenish-yellow petals.

33. M. minimus L. (Sprengel, 'Entd. Geh.,' p. 443; Delpino, 'Altri apparecchi dicog. recent. oss.,' p. 57; Herm. Müller, 'Weit. Beob.,' I, pp. 316–18;

MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1896, pp. 173–4; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 17; Kirchner, 'Flora v. Stuttgart,' p. 262.) — When the flower opens, the slender terminal lobes of the petals are directed outwards, and each secretes in a shallow pit a drop of nectar that is at once visible. The stamens, which are closely pressed against the carpellary cone, dehisce laterally by longitudinal slits, so that their outer surfaces become completely covered with pollen. The small visitors—minute flies and midges—get dusted with pollen below while licking the nectar, and creeping about upon the central cone, transfer pollen from the same or another flower to the stigmas. In young blossoms, where the carpels make up a rounded projection, or at most a short cone, the visitors—according to Müller—usually alight upon its apex, thus effecting cross-pollination. As, however, owing to the inconspicuousness of the flower, insect-visits are very few, automatic self-pollination takes place to a very great extent. For as the flower gets older, its axis—closely beset with carpels—increases greatly in length, so that fresh stigmas are continually being brought to the closely apposed anthers, and are pollinated in regular succession.

According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), in some just-opened flowers, the cone formed by the gynoecium is lower than the stamens which cover it and the stigmas are already mature when the pollen is ripe, hence these flowers are homogamous and autogamous. In other cases, the carpellary cone is elongated and projects from the flower before it opens, and as the stigmas are not mature at this stage, while some of the anthers of the deeply-placed stamens have already dehisced, such flowers are decidedly protandrous. Self-pollination of the central stigmas is in this case precluded, though it may take place in the lower stigmas by further elongation of the axis bearing the carpels.

Visitors. — On the island of Föhr I noticed tiny Muscidae, but did not determine their species. Hermann Müller observed the following at Lippstadt.— **Diptera.** (*a*) *Bibionidae*: 1. Scatopse brevicornis *Mg.* (*b*) *Cecidomyidae*: 2. Cecidomyia sp. (*c*) *Chironomidae*: 3. Chironomus byssinus *Schr.* and other sp. (*d*) *Empidae*: 4. Microphorus sp. (*e*) *Muscidae*: 5. Anthomyia sp., several cases. 6. Hydrellia chrysostoma *Mg.* 7. H. griseola *Fallen.* 8. Oscinis sp. (*f*) *Mycetophilidae*: 9. Sciara sp., 2 sp. in 7 cases. (*g*) *Phoridae*: 10. Phora sp. (*h*) *Syrphidae*: 11. Melanostoma mellina *L.*, a single case.

9. **Batrachium** S. F. Gray

Flowers homogamous or slightly protogynous or protandrous, with half-concealed nectar. The white petals which serve for attraction are usually ornamented at the base with a yellow nectar-guide. Honey is secreted in a pit (open in several northern species, according to Almqvist) at the base of each of them. The stem creeps in mud or floats in water, so that the flowers are accessible only to flying insects and not to creeping ones.

34. B. hederaceum S. F. Gray (=Ranunculus hederaceus *L.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 17–18, 147.)—The diameter of the homogamous flowers is only 4–5 mm. Nectar is sparingly secreted. The 8–10 stamens are in a single whorl, and since they are at the same level as the stigmas, and mature simultaneously, self-pollination must take place should insect-visits fail. This happens very frequently, for, owing to the inconspicuousness of the flower, such visits are

few. On the island of Föhr I observed small flies (Muscidae) visiting the flowers, and of course these might effect self- or cross-pollination with equal facility.

Willis and Burkill ('Fls. and Insects in Gt. Britain.,' I, p. 267) also found flowers in central Wales of only 5 mm. in diameter. They did not observe any secretion of nectar, and saw no insect visitors. The anthers dehisce when the flower opens, and get covered all over with pollen, which they also shed on the stigmas. The stamens move outwards after dehiscence of the anthers. Self-pollination is completely effective. When flowering is over, the peduncle bends downwards during the ripening of the fruit.

35. **B. aquatile** Wimm. (=Ranunculus aquatilis *L.*, in part). (Axell, 'Om anord. för fanerog. Växt. befrukt.,' p. 14; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.,' p. 17; Herm. Müller, 'Fertilisation,' p. 74; 'Weit. Beob.,' I, pp. 318–19; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Crié, C. R. Acad. sci., Paris, ci, 1886, p. 1025; Kirchner, 'Flora v. Stuttgart,' pp. 263–4; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 18, 147.)—The faintly odorous flowers are homogamous or (on the island of Föhr) slightly protogynous. They spread out their petals in the sunshine, forming a yellow-centred white star 20–25 mm. in diameter, but the size varies (and with it the number of stamens) to such an extent that, according to Kirchner, it may be as low as 3–4 mm. (and the number of stamens may be reduced from over 20 to 8). Many insects may, however, be attracted, for the plants are usually associated in large numbers, and not infrequently shallow ditches and ponds are completely filled with them, so that the surface is covered with white blossoms. After the flower has opened, the anthers at once dehisce, covering themselves with pollen. The stigmas usually mature either simultaneously with the stamens or slightly earlier. In the latter case, cross-pollination must result from the visits of insects, if these come from a flower with dehisced anthers. When homogamy obtains, insects may effect either cross- or self-pollination, for they sometimes alight on the centre, sometimes on the margin of the flower, and then creep about. If insect-visits fail, automatic self-pollination takes place, for pollen can readily fall from the anthers on the adjacent stigmas.

When the flowers are submerged in consequence of flooding, they remain closed and pollinate themselves (Axell, Hildebrand).

According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), the flowers are homogamous and autogamous in the neighbourhood of Ruppin. The pollen is yellow, irregularly ellipsoidal, and tuberculated. The grains are about 25 μ broad and 37 μ long.

Visitors.—The following have been observed by Hermann Müller (H. M.) and myself (Kn.).—A. **Coleoptera.** (*a*) *Byrrhidae*: 1. Pedilophorus aeneus *F.*, with its head in the nectaries (H. M.). (*b*) *Chrysomelidae*: 2. Agelastica alni *L.*, resting idly on the flowers (H. M.); 3. Helodes phellandrii *L.*, devouring anthers and flower-leaves (H. M.). (*c*) *Elateridae*: 4. Limonius cylindricus *Payk.*, its head and thorax yellow with pollen. B. **Diptera.** (*a*) *Bibionidae*: 5. Dilophus vulgaris *Mg.* ♂ and ♀, freq. (H. M.). (*b*) *Empidae*: 6. Empis rustica *Fall.* (H. M.); 7. Hilara maura *F.* (H. M.). (*c*) *Muscidae*: 8. Anthomyia sp., skg. and po-cltg. (Kn., Föhr; H. M.); 9. Cyrtoneura hortorum *Fall.* ♂ (H. M.); 10. Hydrellia griseola *Fall.*, skg. and po-cltg., extremely abundant (H. M.); 11. Hylemyia sp. (H. M.); 12. Onesia floralis *R.-D.* ♂, freq. (H. M.); 13. O. sepulcralis *Meig.*, freq. (H. M.); 14. Sarco-

phaga carnaria *L.*, nect-lkg. (Kn., Kiel; H. M.); 15. Scatophaga merdaria *F.*, po-dvg. (H. M.); 16. S. stercoraria *F.*, po-dvg. (Kn., Kiel); 17. Sepsis cynipsea *L.* (Kn., Föhr); 18. Thryptocera sp. (H. M.); 19. Small Muscidae (H. M.); (*d*) *Syrphidae*: 20. Chrysogaster viduata *L.*, skg. and po-dvg. (H. M.); 21. Eristalis arbustorum *L.* (Kn.); 22. E. nemorum *L.* (Kn.); 23. E. tenax *L.* (Kn., all three po-dvg., freq., Kiel; H. M., po-dvg. or skg., feet abundantly smeared with pollen, so as to effect cross-pollination when visiting a fresh flower); 24. Helophilus floreus *L.* (H. M.), and 25. H. pendulus *L.*, both po-dvg. (Kn., Kiel); 26. Melanostoma mellina *L.*, po-dvg. (H. M.); 27. Syrphus sp., po-dvg. (Kn., Kiel). **C. Hymenoptera.** *Apidae*: 28. Apis mellifica *L.* ☿, skg. and po-cltg., freq. (Kn., Kiel and Föhr; H. M.); 29. Bombus terrester *L.* ♀, skg. (H. M.); 30. Halictus minutissimus *K.* ♀, po-cltg., isolated cases (H. M.); 31. H. sexstrigatus *Schenck* ♀, ditto (H. M.). **D. Neuroptera.** 32. Psocus sp., nect-lkg. (Kn., Föhr).

MacLeod, in Flanders, noticed Apis, Megachile, and Eristalis (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 181).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire') Muscidae have been observed.

36. **B. divaricatum** Wimmer (=Ranunculus circinatus *Sibth.*), according to Kirchner, has the same flower mechanism as the last species.

37. **B. paucistamineum** Sonder (=B. trichophyllum *Chaix*, in part). (Knuth, 'Weit. Beob.,' pp. 227–8.)—This plant is very common on the North Frisian islands of Nordstrand and Pellworm. The numerous flowers remain open even in rainy weather, and so abundant and closely massed are the plants in these islands that some ditches look as if they were covered with a white table-cloth. The diameter of the flower is 12–13 mm. Each petal is about 6 mm. long, and about 3 mm. broad towards its tip; the base is marked with a yellow nectar-guide, and is so narrow that there is a considerable space between the individual petals. The plant is slightly protogynous: in just-opened flowers the stigmas are partly mature, while the anthers of the few stamens (usually only 8–12) are still closed. Their ripening goes on centripetally, and the filaments of the 4–6 outer ones elongate, bending towards the petals, so that insects alighting on the middle of the flower effect cross-pollination. The filaments of the 4–6 inner stamens elongate later on, but remain with their dehisced anthers above the stigmas—now very markedly papillose—upon which pollen necessarily falls, thus effecting self-pollination automatically. This must be effective, for all the carpels constantly mature, though I have not observed any insect-visits, despite long watching during favourable weather.

38. **B. (Ranunculus) paucistamineum** Tausch (not Sonder) was found by Schulz—in central Germany—to be either homogamous or slightly protandrous, with very great variation in the size of the flowers and the number of stamens. He also observed gynomonoecism. According to Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896), the flowers at Neuruppin are protogynous, and their diameter is 10–17 mm. They possess as many as 15 stamens, which are shorter than the head of carpels. Pollen: golden yellow, roughly tuberculate, varied in form, ellipsoidal or bluntly conical, with three longitudinal furrows, 20–43 μ long and 25–30 μ broad. According to Freyn, the submerged flowers are sterile.

39. **B. fluitans** Wimmer (=Ranunculus fluitans *Lmk.*).—According to Freyn, this is usually sterile because the flowers are submerged. The fruits were set,

however, in herbarium specimens, which were obtained from eastern Schleswig-Holstein, and from the island of Röm.

40. **B. carinatum** Schur.—Freyn states that the very long peduncles—which are at right angles to the surface—are not submerged by the rising of the water.

41. **B. Baudotii** d. B.—

VISITORS.—Verhoeff observed one of the Muscidae in Norderney (Anthomyia sp., skg., one instance).

10. Ranunculus *L.*

Flowers homogamous or—more rarely—slightly protogynous or protandrous, with nectar half concealed. Insects are attracted by the petals, which are usually yellow, but white or red in a few species. At the base of each petal there is a nectar-pit, that is either upwardly prolonged into a membranous scale (in the species with white or red flowers), or (in most yellow-flowered species) covered by a fleshy upwardly directed scale, or else it is open (in R. sceleratus, and—according to Almqvist—in a few northern species (R. pygmaeus *Wg.*, R. hyperboreus *Rottb.*, R. nivalis *L.*)). Many species have flowers that repeatedly open and close. On dehiscence of the anthers the stamens incline towards the petals, so that the pollen falls upon these, but not so readily upon the stigmas. Only the larger nectar-sucking, pollen-collecting, or pollen-devouring insects come regularly into contact with the stigmas, effecting self- or cross-pollination with equal ease. The larger the flowers the less likely is automatic self-pollination, for with increased size the distance between anthers and stigmas of course becomes greater, and there is less chance of pollen falling upon the stigmas when the blossoms are bent by the wind or any other agency. But as increase of size in the flowers furthers the visits of insects—with resultant pollination—this disadvantage is counterbalanced.

The flowers are sometimes gyno-monoecious, while according to Schulz, gyno-dioecism occurs in R. acris, auricomus, hybridus, and repens, and the same condition has also been observed in England by Whitelegge in the case of R. bulbosus.

42. **R. glacialis** L. (Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e. subalp.'; Lindman, 'Bidrag till Känned. om Skand. fjellväxt. blom. o. befrukt.'; Herm. Müller, 'Alpenblumen,' pp. 128–9; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora.')—The flowers are homogamous or—according to Ricca—slightly protandrous. In the Scandinavian highlands they are markedly protandrous. Some may be female only. In old flowers automatic self-pollination can easily be effected by the fall of pollen from the anthers of the inner stamens upon the stigmas. In the Alps the size of the flower varies greatly (12–30 mm. in diameter). The structure of the nectaries is equally varied (see Fig. 5). Besides hermaphrodite blossoms, Kerner observed pseudo-hermaphrodite pollen flowers. He also found two forms of hermaphrodite flower, corresponding to those of Anemone alpina. Andersson and Hesselman state (op. cit., p. 42) that this species was frequently found in flower in Spitzbergen during July.

VISITORS.—Müller observed—in the Alps—2 flies and 2 micro-Lepidoptera.

43. **R. lapponicus** L.—This species flowers in Spitzbergen from the middle of July to the middle of August, and though ripe fruits have not so far been seen, they were observed to be set in 1897 and 1898. Of the pollen-grains 96 % were normally developed (Andersson and Hesselman, op. cit., pp. 43–7). Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 227) describes the flowers in the same locality as being yellow, fragrant and protogynous-homogamous, with a diameter of 8–10 or sometimes even 13 mm. Andersson and Hesselman state that the pouch-like nectar-pits are relatively smaller than those of R. Pallasii.

For Nova Zemlia Ekstam gives the diameter of the protogynous-homogamous flowers as 16 mm. (according to Kjellman, it is 12 mm. in Arctic Siberia). Self-pollination is excluded, for the stigmas project beyond the anthers.

44. **R. Pallasii** Schlecht.—This species flowers in Spitzbergen during the end of July and the beginning of August, but perfectly ripe fruits have not so far been observed. Andersson and Hesselman (op. cit., p. 42) state that 96–98 % of the pollen-grains are normally developed. According to Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' pp. 21–2), the white or greenish-white flowers are about 15 mm. in diameter. Nathorst says that their odour is extremely pleasant, resembling that of Platanthera. Andersson and Hesselman state that nectar is secreted in a nectar-pit situated in the upper part of the small claw. Ekstam found the flowers to be protogynous-homogamous.

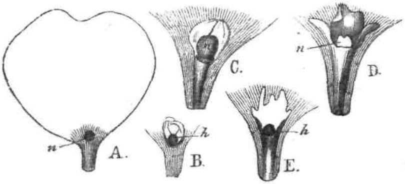

FIG. 5. *Ranunculus glacialis*, *L.* (after Herm. Müller). *A.* Petal of a flower with particularly small perianth (× 7). *B–E.* Bases of other petals with variously formed nectaries (× 7).

VISITORS.—Ekstam (op. cit.) noticed one medium-sized and a number of small 'industrious' Diptera.

45. **R. lapponicus × R. Pallasii.**—This hybrid was noticed beneath the parent species in Spitzbergen by Nathorst in 1882, and subsequently in 1898 by Andersson and Hesselman (op. cit., pp. 42–7). Its characters are an approximately equal blend of those of the component species. The flowers are yellowish-white, fragrant, and about 10–13 mm. in diameter. Only 8–12 % of the pollen-grains develop normally. The flowers are protogynous-homogamous; nectar is sparingly secreted by the pouch-shaped nectar-pits. The plant was seen in flower from the end of July on into August, but fruits have so far been observed only in the earlier stages of development. The occurrence of this interesting hybrid shows that the fruits of the mother-plant can actually ripen.

46. R. sulphureus Sol.—According to Ekstam, the diameter of the flowers is 16 mm.; in Arctic Siberia (Kjellman) and on Nova Zemlia it is distinctly greater. In Spitzbergen this observer (op. cit., p. 23) found the flowers to be protogynous-homogamous, and faintly fragrant. In expanded blossoms the gynoecium projects so far beyond the stamens that autogamy is prevented. Andersson and Hesselman (op. cit., p. 49) state that this species flowers in Spitzbergen from the end of June until August, the fruits being ripe at the end of the latter month—or much earlier near the deep fjords.

VISITORS.—Ekstam observed seven distinct cases in Spitzbergen where the flowers were visited by numerous Diptera, and he also noticed these insects elsewhere.

47. R. pyrenaeus L. (Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.,' p. 3; Herm. Müller, 'Alpenblumen,' pp. 132–3; MacLeod, 'Pyreneenbl.,' p. 114.)—In this species the nectaries are also very variable, as the accompanying figure shows (Fig. 6). According to Ricca, cross-pollination is at first favoured by feebly

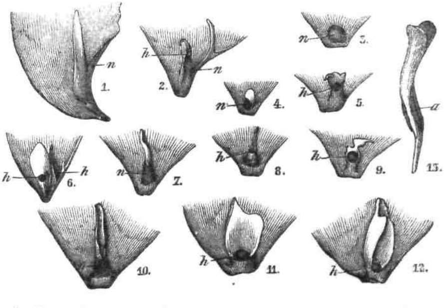

FIG. 6. *Ranunculus pyrenaeus, L.* (after Herm. Müller). 1–12. Various forms of nectary. *h*, nectar. 13. Transition from petal to stamen.

marked protogyny. Subsequently—according to Müller—cross- and self-pollination are equally possible as the result of insect-visits. During this stage, automatic self-pollination by means of the inner stamens can easily take place.

VISITORS.—Hermann Müller observed—in the Alps—2 beetles, 9 flies, one Ichneumon, and one micro-Lepidopterid. MacLeod observed—in the Pyrenees—2 flies.

48. R. alpestris. L. (including R. Traunfellneri *Hoppe*). (Herm. Müller, 'Alpenblumen,' pp. 130–1; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II.) — According to Müller, cross-pollination is at first favoured in the homogamous or slightly protogynous flowers, but afterwards self-pollination is possible. The hermaphrodite flowers—according to Kerner—occur in two forms, as in Anemone alpina. Kerner also observed pseudo-hermaphrodite pollen flowers.

VISITORS. — Hermann Müller observed 19 flies, one beetle, one humble-bee, and 2 Lepidoptera.

49. **R. aconitifolius** L. (Herm. Müller, 'Alpenblumen,' p. 131; Schulz, 'Beiträge.')—According to Schulz, the flowers are markedly protandrous in the Riesengebirge. Most of the plants in this district bear blossoms of very varied size, and therefore have a characteristic appearance.

VISITORS.—Müller observed the following in the Alps.—7 beetles, 18 flies, 6 Hymenoptera, and 4 Lepidoptera.

50. **R. Seguieri** Vill.—At San Martino—according to Schulz—some stocks bear purely male flowers.

51. **R. parnassifolius** L. (Herm. Müller, 'Alpenblumen,' p. 132.)—The flowers are protogynous with stigmas that persist for a long time, so that cross-pollination is at first secured. Self-pollination by the inner stamens becomes possible

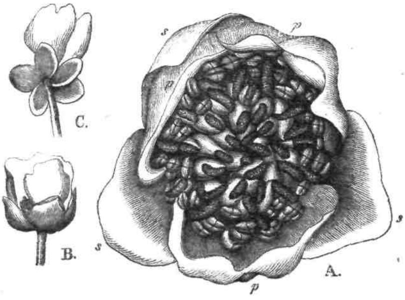

FIG. 7. *Ranunculus parnassifolius*, L. (after Herm. Müller). *A*. Flower in first (female) condition, seen from above (× 7). All the stigmas are mature, while all the anthers are still closed. *B*. Flower with five sepals, and two petals, seen from the side (natural size). *C*. The same with one petal, oblique view from below (natural size).

later on. Usually only one petal is developed, though sometimes there are two or three (cf. Fig. 7).

VISITORS.—In the Alps these are chiefly flies (Muscidae and Syrphidae).

52. **R. amplexicaulis** L.—The flowers are white.

VISITORS.—MacLeod observed—in the Pyrenees—one bee, one hover-fly, and 2 Muscidae.

53. **R. Gouani** Willd.—

VISITORS.—MacLeod observed—in the Pyrenees—3 species of bee, one hover-fly, and 5 species of Muscidae.

54. **R. hyperboreus** Rottb.—Lindman states that the flowers are slightly protandrous in the Scandinavian highlands, and the numerous stigmas project so far above the anthers that automatic self-pollination is impossible. In the Arctic regions, throughout which the species is widely distributed, the flowers are remarkably small and—according to Warming—they are autogamous.

Vanhöffen (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' p. 30) observed this species in partially flooded places in Greenland. The leaves projected beyond the small flowers.

55. **R. paucistamineus** Tausch, var. *eradicata* Laestad. (=R. confervoides *Fries*, in Lange's 'Consp. flor. groenl.').—Vanhöffen (Abromeit, op. cit., pp. 29–30) found this species with mature fruits in ponds in Greenland.

56. **R. pygmaeus** Wg.—Ekstam states that the flowers are homogamous in the Scandinavian highlands. Their diameter there is 7 or 4 mm., and on Nova Zemlia 5–10 mm. The stigmas, especially in the small flowers, stand at the same level as the anthers, so that automatic self-pollination must take place, and this is effective in Scandinavia and Nova Zemlia; also in other parts of the Arctic regions, as Warming has shown.

Andersson and Hesselman (op. cit., p. 48) say that the species flowers in Spitzbergen from the end of July to the middle of August, and is in blossom on Beeren Island by the middle of June. The fruits mature early, many of them being ripe at the beginning of August, or later. Little pollen is produced, but this develops normally. Self-pollination is brought about by contact of the dehisced anthers with the stigmas of the lower carpels. According to Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' pp. 22–3), the flowers are 5–8 mm. broad and non-fragrant. They are feebly protandrous, all the anthers having as a rule dehisced before the stigmas have completely matured.

57. **R. Flammula** L. (Herm. Müller, 'Fertilisation,' pp. 74–6, 'Weit. Beob.,' I, p. 319; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney,' p. 127; Kirchner, 'Flora v. Stuttgart,' p. 265; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 175; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 18, 147.)—The bright yellow blossoms are protandrous. Immediately after the flower has opened, the anthers of the outermost stamens dehisce, so that their outer sides are covered with pollen, some of which must adhere to insects seeking the nectar secreted by the bases of the petals. At this stage the incompletely mature stigmas are completely, or almost completely, covered by the inner stamens, being thus guarded from contact with insect visitors. Centripetal dehiscence of the anthers slowly takes place, each stamen in turn bending outwards, so as to direct its pollen-covered side towards the petals. The stigmas are mature before the anthers of the innermost stamens have dehisced. Should insects covered with pollen alight on the middle of the flower, crossing must result, while if they settle upon a petal, afterwards creeping over the stamens to the stigmas, there is an equal chance of self-pollination, which at this stage may also take place automatically. Herm. Müller states that the two modes of alighting are about equally common in this and the next three species.

Visitors.—In consequence of its relatively small flowers, R. Flammula attracts but few insects. The following have been observed by Hermann Müller (H. M.), Verhoeff (V.) in Norderney, and by myself (Kn.) in Schleswig-Holstein.—**A. Coleoptera.** *Staphylinidae*: 1. Anthobium minutum *F.*, freq. (H. M., Teutoburger Wald). **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp. (Kn., Föhr; H. M., V.); 3. Scatophaga merdaria *L.*, po-dvg. (H. M.); 4. S. stercoraria *F.*, po-dvg. (Kn., Kiel). (*b*) *Syrphidae*: 5. Cheilosia sp., po-dvg. (H. M.); 6. Eristalis tenax *L.*, po-dvg. (Kn., Kiel); 7. Melithreptus taeniatus *Mgn.*, po-dvg. and skg. (H. M.);

8. Syritta pipiens *L.*, po-dvg. and skg. (Kn., Kiel, H.M.). **C. Hymenoptera.** *Apidae:* 9. Apis mellifica *L.* ☿, skg. and po-cltg. (Kn., Kiel); 10. Halictus cylindricus *F.* ♀, po-cltg. (H. M.); 11. H. flavipes *F.* ♀, po-cltg. (H. M.). **D. Lepidoptera:** 12. Coenonympha pamphilus *L.*, skg. (H. M.).

Alfken and Hoppner observed—at Bremen—the small bee Dufourea vulgaris *Schenck* ♀ and ♂, skg., freq.

H. de Vries (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875), observed in the Netherlands a bee, Trachusa serratulae *Pz.* MacLeod—in Flanders—saw a short-tongued bee, 3 hover-flies, and a Muscid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 175–6).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 4) Muscidae and various hover-flies have been observed.

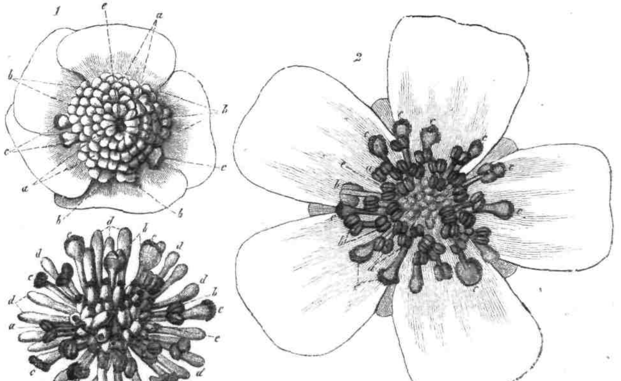

FIG. 8. *Ranunculus Flammula*, *L.* (after Herm. Müller). 1. Flower just opening: the anthers of some of the marginal stamens have dehisced. 2. Flower in the first (male) condition: all the anthers have dehisced; the stigmas are still immature. 3. Flower in the second (hermaphrodite) condition: the stigmas are fully mature, some of the anthers are still covered with pollen. *a*, immature stamens; *b*, anthers about to dehisce; *c*, stamens with dehisced anthers; *d*, stamens with empty anthers; *e*, carpel.

58–60. R. acris L., **R. repens** L., and **R. bulbosus** L.—Herm. Müller ('Fertilisation,' pp. 76–7) states that these agree with R. Flammula in the structure of their flowers, but receive more insect-visits owing to their greater conspicuousness. The visitors are chiefly pollen-loving hover-flies (Syrphidae), which are attracted by the bright blossoms and easily find the half-concealed nectar. Other frequent guests are small bees, especially species of Halictus, which readily collect the abundant pollen with their tarsal brushes, and with their moderately short proboscides easily reach the nectar, for this—though hidden—is not difficult of access. These insects and flowers—as Herm. Müller puts it—are at correspondingly low stages of develop-

ment, and exhibit complete mutual adaptation as regards both size and general structure.

Lindman states that on the Dovrefjeld the flowers of R. acris sometimes possess an agreeable, slightly sweet odour: the diameter of the flowers is 15–25 mm.: the visitors are numerous flies, and also Lepidoptera. According to Ekstam, flowers of the variety borealis *Trautv.*—in Nova Zemlia—have a diameter of 30 mm., and are slightly protogynous, protogynous-homogamous, protandrous-homogamous, or homogamous. Flies were observed as visitors. In central Germany, Schulz also observed gynomonoecism.

R. repens—according to Lindman—is also homogamous on the Trontfjeld. Schulz states that this species also is gynodioecious in central Germany.

The same is true—according to Whitelegge—for R. bulbosus in England.

The species R. repens, R. acris, and R. Flammula[1] exhibit in the East Frisian islands (Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney,' pp. 108–14) three very important and interesting degrees of adaptation to insects. The actual kind and frequency of insect-visits harmonize most beautifully with these adaptational stages. Verhoeff says that R. repens has an advantage over R. acris in the following characters:—(1) the nectary and nectar-scale are better developed; (2) the stamens diverge outwards more readily, usually projecting beyond the calyx—which seldom happens in R. acris; (3) the petals are broader and more lustrous; and (4) the flowers are more crowded.

Verhoeff makes the following comparison between R. acris and R. repens on the one hand, and R. Flammula on the other, with regard to the times at which the sexes develop.—

R. acris and R. repens.	R. Flammula.
The stigmas are mature before any of the anthers have dehisced, and are at the same time exposed to contact with the under-sides of insects.	The stigmas are undeveloped when the first marginal anthers dehisce, but mature while the rest of the outer anthers are ripening.
In flowers where all or some of the innermost anthers have dehisced, the carpels are already swollen and their stigmas shrivelled.	
The stigmas may either be a little higher or a little lower than the adjacent anthers.	The stigmas project above the adjacent anthers from the first.
Protogyny.	Approach to protogyny.

In Westphalia, Hermann Müller has not noticed any differences between R. acris, R. repens, and R. bulbosus. On the contrary, he expressly remarks

[1] Verhoeff says: 'H. Müller has made a mistake with regard to the species of Ranunculus, wrongly asserting that R. acris, repens, and Flammula agree as regards structure and conspicuousness.' This, however, is not quite correct, for Hermann Müller expressly states that R. Flammula is much more rarely visited by insects than R. acris, R. repens, and R. bulbosus—'One reason at least being that its flowers are much smaller, and less conspicuous.' ('Fertilisation,' p. 76.)

that they agree 'with each other in their habitat, in the conspicuousness of their flowers, and therefore also in the insects which visit them .... I have even noticed the hive-bee, which in general keeps strictly to one species of flower, passing from *Ranunculus acris* to *R. repens* and *R. bulbosus*, or *vice versa*, without any distinction.' ('Fertilisation,' p. 76.)

VISITORS.—On the North Frisian islands I have noticed the following for these three species.—Small bees, 7 hover-flies, 2 Muscidae, one butterfly, one beetle. Also the following in Schleswig-Holstein (S-H.), Helgoland (H.), Thuringia (Th.), and Rügen (R.).—**A. Coleoptera.** *Nitidulidae*: 1. Meligethes sp. (S-H.). **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp. (S-H., Th.); 3. Aricia basalis *Zett.* (Th.); 4. A. incana *Wied.* (S-H.); 5. Coelopa frigida *Fall.* (H.); 6. Fucellia fucorum *Fall.* (H.); 7. Homalomyia scalaris *F.* ♂ (H.); 8. Small Muscids, freq. (H., S-H.). (*b*) *Syrphidae*: 9. Chrysogaster macquarti *Loew* (S-H.); 10. Eristalis arbustorum *L.* ♂, skg. (S-H., R.); 11. E. tenax *L.* (S-H.); 12. Helophilus pendulus *L.* (S-H.); 13. Melanostoma mellina *L.* (S-H.); 14. Syritta pipiens *L.* (S-H.); 15. Syrphus cumulatus *Mgn.* (Th.); 16. S. sp. (S-H.). **C. Hymenoptera.** (*a*) *Apidae*: 17. Short-tongued bees (S-H.). (*b*) *Vespidae*: 18. Vespa salonica *F.* ♀ (Th.). **D. Lepidoptera.** *Rhopalocera*: 19. Lycaena semiargus *Rott* (S-H.); 20. Leucophasia sinapis *L.* (S-H.).

MacLeod observed in Flanders:—Apis, 12 short-tongued Hymenoptera, 12 hover-flies, 11 other flies, 2 Lepidoptera, and 2 beetles (Bot. Jaarb. Dodonaea, Ghent, vi. 1894, pp. 176–7).

By far the largest number of visitors has been observed by Hermann Müller (H. M.) in Westphalia, and his friend Dr. Buddeberg (Budd.) in Nassau. The following list gives the results of their observations, along with a few made by Borgstette (Borg.) in Tecklenburg.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (H. M., Budd.). (*b*) *Cerambycidae*: 2. Strangalia nigra *L.* (H. M.), gnawing the flowers. (*c*) *Chrysomelidae*: 3. Cryptocephalus sericeus *L.* (H. M.), as the last; 4. Galleruca nymphaeae *L.* (H. M.); 5. Prasocuris glabra *Hbst.* (H. M.), gnawing the flowers. (*d*) *Cistelidae*: 6. Cistela murina *L.* (H. M.), as the last. (*e*) *Coccinellidae*: 7. Micraspis duodecim punctata *L.*, vainly skg. (H. M.). (*f*) *Curculionidae*: 8. Bruchus sp., nect-lkg. (H. M.). (*g*) *Dermestidae*: 9. Byturus fumatus *F.*, po-dvg., freq. (H. M.). (*h*) *Elateridae*: 10. Limonius cylindricus *Payk.*, nect-lkg. (H. M.). (*i*) *Malacodermata*: 11. Malachius aeneus *L.* (H. M.), and 12. M. bipustulatus *F.*, both devouring anthers (H. M.); 13. Trichodes apiarius *L.*, po-dvg. (H. M.). (*k*) *Mordellidae*: 14. Mordella aculeata *L.* (H. M.); 15. M. pusilla *Dej.* (H. M.). (*l*) *Nitidulidae*: 16. Meligethes brassicae *Scop.*, po-dvg. (H. M.); 17. M. sp., very freq., skg. and po-dvg. (H. M.). (*m*) *Oedemeridae*: 18. Oedemera virescens *L.*, freq. (*n*) *Staphylinidae*: 19. Tachyporus solutus *Er.*; 20. Anthobium minutum *F.*, very freq., Teutob. Wald.

B. Diptera. (*a*) *Asilidae*: 21. Dioctria atricapilla *Mg.* (Borg.). (*b*) *Empidae*: 22. Empis stercorea *L.*, skg. (H. M.); 23. E. tessellata *F.*, skg. (H. M.); 24. Rhamphomyia umbripennis *Mg.*, skg. (H. M.). (*c*) *Muscidae*: 25. Anthomyia sp. (H. M.); 26. Calobata cothurnata *Pz.* (H. M.); 27. Cyrtoneura caerulescens *Mcq.*, skg. (H. M.). (*d*) *Stratiomyidae*: 28. Odontomyia tigrina *F.*, skg. (H. M.). (*e*) *Syrphidae*: 29. Cheilosia albitarsis *Mg.*, freq., skg. and po-dvg. (H. M.); 30. C. pubera *Zett.*, po-dvg., in large numbers (H. M.); 31. C. schmidtii *Zett.*, skg. and po-dvg. (H. M.); 32. C. vidua *Mg.*, skg. and po-dvg. (H. M., Budd.); 33. Chrysochlamys ruficornis *F.*, po-dvg. (H. M.); 34. Chrysogaster macquarti *Loew* (H. M.); 35. C. viduata *L.*, very freq., skg. and po-dvg. (H. M.); 36. Chrysotoxum arcuatum *L.*, skg. and po-dvg. (H. M.); 37. C. festivum *L.*, skg. (H. M.); 38. Eristalis arbustorum *L.* (H. M.); 39. E. nemorum *L.* (H. M.); 40. E. sepulcralis *L.* (H. M.), and 41. E.

tenax *L.*, all four freq., skg. and po-dvg. (H. M.); 42. Melanostoma mellina *L.*, skg. (H. M.); 43. Melithreptus pictus *Mg.* (H. M.); 44. M. scriptus *L.* (H. M.), and 45. M. taeniatus *Mg.* (H. M.), all three freq., skg. and po-dvg.; 46. Pipiza chalybeata *Mg.*, po-dvg. (H. M.); 47. P. funebris *Mg.*, skg. (H. M.); 48. Platycheirus albimanus *F.*, po-dvg. (Borg.); 49. Syritta pipiens *L.*, freq., skg. and po-dvg. (H. M.); 50. Syrphus pyrastri *L.*, po-dvg. (H. M.); 51. S. ribesii *L.*, freq., skg. and po-dvg. (H. M.).

C. Hymenoptera. (*a*) *Apidae*: 52. Andrena albicans *Müll.* ♀ and ♂, freq., skg. and po-dvg. (H. M., Budd.); 53. A. albicrus *K.* ♂, freq., skg. and po-dvg. (H. M.); 54. A. flavipes *Pz.* ♀ and ♂, freq., skg. and po-dvg. (H. M.); 55. A. gwynana *K.* ♂, skg. and po-cltg. (Budd.); 56. A. trimmerana *K.* ♂, skg. (H. M.); 57. Apis mellifica *L.* ♀, skg. (H. M., Budd.); 58. Bombus agrorum *F.*, skg. while on the wing (H. M.); 59. Eriades florisomnis *L.* ♂ and ♀, skg. (H. M., Budd.); 60. E. nigricornis *Nyl.* ♂, skg. (Budd.); 61. Halictus albidulus *Schenck* ♀, skg. and po-cltg. (H. M.); 62. H. albipes *F.* ♀, skg. and po-cltg. (Budd.); 63. H. cylindricus *F.* ♀, po-cltg. and skg. (H. M., Budd.); 64. H. flavipes *F.* ♀, po-cltg. (H. M.); 65. H. leucopus *K.* ♀, skg. (Budd.); 66. H. leucozonius *Schr.* ♀, skg. and po-cltg. (H. M., Budd.); 67. H. longulus *Sm.* ♀, skg. (H. M.); 68. H. lugubris *K.* ♀ and ♂, skg. and po-cltg. (H. M.); 69. H. maculatus *Sm.* ♀, skg. and po-cltg. (H. M., Budd.); 70. H. morio *F.* ♀, skg. (Budd.); 71. H. nitidiusculus *K.* ♀, skg. and po-cltg. (H. M., Budd.); 72. H. rubicundus *Chr.* ♀, skg. and po-cltg. (H. M., Budd.); 73. H. sexnotatus *K.* ♀, skg. and po-cltg. (H. M., Budd.); 74. H. sexsignatus *Schenck* ♀, skg. (H. M.); 75. H. smeathmanellus *K.* ♀, skg. and po-cltg. (Budd.); 76. H. tetrazonius *Klg.* ♀, skg. and po-cltg. (H. M.); 77. H. villosulus *K.* ♀, skg. and po-cltg. (H. M., Budd.); 78. H. zonulus *Sm.* ♂, skg. (H. M.); 79. Osmia aenea *L.* ♂, skg. (Budd.); 80. O. rufa *L.* ♀, po-cltg. (H. M., Budd.); 81. Panurgus calcaratus *Scop.*, skg. (H. M.); 82. Prosopis brevicornis *Nyl.* ♂, skg. (Budd.); 83. P. clypearis *Schenck* ♂, skg. (Budd.); 84. P. hyalinata *Sm.* ♂, skg. and po-dvg. (H. M.). (*b*) *Formicidae*: 85. Lasius niger *L.* ☿, nect-lkg. (H. M.). (*c*) *Sphegidae*: 86. Oxybelus uniglumis *L.* (H. M.). (*d*) *Tenthredinidae*: 87. Amasis crassicornis *Rossi* (H. M.); 88. Cephus pallipes *Klg.*, nect-lkg. (Budd.); 89. C. pygmaeus *L.*, by the hundred, skg. and devouring the anthers (H. M.); 90. C. small undetermined sp. (H. M.). (*e*) *Vespidae*: 91. Odynerus spinipes *L.* ♀ (H. M.).

D. Lepidoptera. (*a*) *Rhopalocera*: 92. Coenonympha pamphilus *L.* (H. M.); 93. Lycaena icarus *Rott.* (H. M., Budd.); 94. Pararge achine *Scop.* (Budd.); 95. Polyommatus dorilis *Hfn.* (H. M.); and 96. P. phlaeas *L.*; all skg. (H. M.). (*b*) *Noctuidae*: 97. Euclidia glyphica *L.* (*c*) *Tineidae*: 98. Micropteryx calthella *L.*, very frequent in R. repens, skg. (Dr. Speyer).

E. Thysanoptera. 99. Thrips, frequent (H. M.).

Hermann Müller ('Alpenblumen,' p. 135) observed in the Alps R. acris *L.* visited by 2 beetles, 2 hover-flies, 2 Tenthredinidae, and 11 Lepidoptera: R. repens *L.* visited by 4 beetles, 5 flies, 5 Hymenoptera, and 6 Lepidoptera: R. bulbosus *L.* visited by Hymenoptera.

Verhoeff observed the following on Ranunculus acris in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes brassicae *Scop.*, skg.; 2. M. coracinus *St.* **B. Diptera.** (*a*) *Dolichopidae*: 3. Dolichopus aeneus *D. G.*, one ♂. (*b*) *Empidae*: 4. Hilara quadrivittata *Mg.*, skg. (*c*) *Muscidae*: 5. Anthomyia pratensis *Mg.*, po-dvg. and skg.; 6. A. sp., po-dvg. and skg.; 7. Aricia incana *Wied.*, po-dvg.; 8. Lucilia caesar *L.*, skg.; 9. Onesia floralis *R.-D.*, ♀ and ♂, skg. (*d*) *Syrphidae*: 10. Eristalis sepulcralis *L.*, one ♂; 11. Melanostoma mellina *L.*, one ♀; 12. Pipizella virens *F.*; 13. Platycheirus albimanus *F.* ♂, po-dvg.; 14. P. manicatus *Mg.* ♀, po-dvg. and skg.

Von Dalla Torre observed in the Tyrol the bees Andrena rosae *Pz.* ♂; A. tibialis *K.* ♂; A. bicolor *F.* (= A. Gwynana *K.*) ♂; A. fulvicrus *K.* ♀; Halictus albipes *F.* ♀; H. smeathmanellus *K.* ♀ and ♂; Osmia caerulescens *L.* ♂; Chelostoma maxillosum *L.* ♂, very freq.

Loew observed the following on Ranunculus acris in the Berlin Botanic Garden.—*Apidae*: Andrena nitida *Fourc.* ♀, skg. and po-cltg.; in Brandenburg,—Pipiza quadrimaculata *Pz.*, skg.; in Silesia, —*Syrphidae*: 1. Syrphus tuniger *Mg.*; 2. S. cumulatus *Mg.*; 3. Melithreptus scriptus *L.*, skg., and also Meligethes nect-lkg. He also noticed the following in Switzerland ('Beiträge,' p. 57).—

A. Coleoptera. *Buprestidae*: 1. Anthaxia quadripunctata *L.* **B. Diptera.** *Muscidae*: 2. Hydrotaea ciliata *F.*; 3. Tetanocera elata *Fr.* **C. Hymenoptera.** *Apidae*: 4. Panurgus banksianus *K.* ♀, po-cltg.; Ricca (Atti Soc. ital. sc., Milano, xiii. 1870) mentions this.

Schletterer enumerates the following bees for the Tyrol:—1. Andrena austriaca *Pz.*; 2. A. flavipes *Pz.*; 3. A. gwynana *K.*; 4. A. tibialis *K.*; 5. Eriades florisomnis *L.*; 6. Halictus albipes *F.*; 7. H. smeathmanellus *K.*; Osmia caerulescens *L.*

MacLeod observed in the Pyrenees 4 short-tongued Hymenoptera, one of the Lepidoptera, 2 beetles, 3 Syrphidae, and 6 Muscidae ('Pyreneenbl.,' p. 387).

Alfken—in Bremen—noticed the following on Ranunculus repens and R. acris.—

A. Diptera. (*a*) *Bibionidae*: 1. Bibio marci *L.*; 2. Dilophus vulgaris *L.* (*b*) *Syrphidae*: 3. Ascia podagrica *L.*; 4. Eristalis arbustorum *L.*; 5. E. sepulcralis *L.*; 6. Melanostoma mellina *L.*; 7. Rhingia rostrata *L.*; 8. Syritta pipiens *L.*

B. Hymenoptera. (*a*) *Apidae*: 9. Andrena albicans *Müll.* ♀; 10. A. nigroaenea *K.* ♀; 11. Bombus terrester *L.* ♀; 12. Eriades florisomnis *L.* ♀ and ♂: 13. Osmia rufa *L.* ♀; (*b*) *Tenthredinidae*: 14. Cephus nigrinus *Ths.* (not on R. acris).

H. De Vries ('Ned. Kruidk. Arch.,' Nijmegen, 2. ser., 2. deel, 1875) observed—in the Netherlands—2 bees: Andrena trimmerana *K.* ♀, and Eriades florisomnis *L.* ♂.

In Dumfriesshire (Scott-Elliott, 'Flora of Dumfriesshire,' p. 5), Muscidae, Empidae, Syrphidae, Tenthredinidae, and Meligethes have been observed on R. acris and R. repens.

Loew observed in Brandenberg ('Beiträge,' p. 38) on the flowers of R. repens,—Eriades florisomnis *L.* ♀, po-cltg.; as did Schenck in Nassau, and Schletterer and von Dalle Torre in the Tyrol.

Verhoeff observed the following on R. repens in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Brachypterus gravidus *Ill.*, skg.; 2. Meligethes aeneus *L.* **B. Diptera.** (*a*) *Empidae*: 3. Hilara quadrivittata *Mg.*, skg. (*b*) *Muscidae*: 4. Anthomyia sp.; 5. Aricia incana *Widem.* ♀ and ♂, po-dvg. and skg.; 6. Calliphora erythrocephala *Mg.* one ♀; 7. Cyrtoneura hortorum *Fall.*; 8. Lucilia caesar *L.* ♀ and ♂, skg.; 9. Onesia floralis *R.-D.* ♀ and ♂. (*c*) *Syrphidae*: 10. Chrysogaster metallina *F.*; 11. Eristalis arbustorum *L.*, three ♂; 12. E. sepulcralis *L.*, one ♂, skg.; 13. Melanostoma mellina *L.*; 14. Platycheirus manicatus *Mg.*, po-dvg. and skg. **C. Hymenoptera.** *Formicidae*: 15. Formica fusca *L.* (= Rasse fusca *Forel*), one ♀. **D. Lepidoptera.** *Pieridae*: 16. Pieris brassicae *L.*, one ♀, skg.

In Switzerland Loew observed ('Beiträge,' p. 57).—

Diptera. *Syrphidae*: 1. Cheilosia antiqua *Mg.*, po-dvg.; 2. Merodon cinereus *F.*, po-dvg.

H. de Vries (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875)—in the Netherlands—noted the following.—**Hymenoptera.** 1. Apis mellifica *L.* ☿; 2. Eriades florisomnis *L.* ♂; 3. Halictus leucozonius *K.* ♀; 4. Panurgus banksianus *Latr.* ♂; a wood-wasp (*Siricidae*); *Cephus pygmaeus L.*

As visitors of R. bulbosus,—Cetonia hirtella *L.*, was observed by Loew in Brandenburg ('Beiträge,' p. 38); the bee Andrena humilis *Imt.*, by Schmiedeknecht in Thuringia; the bee Andrena cingulata *F.*, by Schenck, in Nassau; and the bee Eriades florisomnis *L.* ♂, by H. de Vries, in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

MacLeod observed in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 387–8):—3 short-tongued Hymenoptera, 2 Lepidoptera, one of the Syrphidae, and 3 Muscidae.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 5) there have been observed—Apis, one humble-bee, one saw-fly, and 2 Muscidae.

61. **R. Lingua** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 18–20; 'Blütenbiol. Beob. a. d. Ins. Rügen') has been studied by myself on Föhr and at Kiel. The stem is branched above and one metre high. It bears a number of large golden-yellow flowers, with a diameter of about 4 cm., so that the plant is conspicuous at a distance. Each petal bears at its base a large richly secreting nectary. The flowers are protogynous. After the numerous stigmas have matured centripetally, the anthers dehisce extrorsely in similar order. The stamens bend outwards towards the expanded petals as they ripen, so that automatic self-pollination is rendered very difficult. But owing to the oblique position of the flower it can take place, though it appears to be ineffective, for frequently but few fruits are formed, and not rarely none at all. Cross-pollination is effected by the agency of flies, which nearly always alight on the middle of the flower, so that if already covered with pollen they dust the stigmas on their way to the anthers and nectaries.

Visitors.—I observed the following in Schleswig-Holstein.—**Diptera.** (*a*) *Muscidae*: 1. Aricia incana *Wied.*, nect-lkg. and po-dvg. (Föhr); 2. Small Muscidae, as before; 3. Calliphora erythrocephala *Mg.* (Kiel); 4. Lucilia caesar *L.*, as before; 5. Sarcophaga carnaria *L.*, as before (Föhr). (*b*) *Syrphidae*: 6. Eristalis arbustorum *L.*; 7. E. tenax *L.*; 8. Rhingia rostrata *L.*; 9. Syrphus balteatus *Deg.*; 10. S. ribesii *L.*; 11. Syritta pipiens *L.*, all skg. and po-dvg.

Besides these I observed in the island of Rügen.—**A. Diptera.** *Odontomyidae*: 1. Chrysomyia formosa *Scop.*, skg. **B. Lepidoptera.** *Hesperidae*: 2. Hesperia lineola *O.*, skg.

62. **R. hybridus** Biria.—Schulz states that this species is homogamous, or slightly protandrous, in the Tyrol. The flowers vary greatly in size and in the number of the stamens. Schulz also observed gynomonoecism.

63. **R. auricomus** L. (Sprengel, 'Entd. Geh.,' p. 294; Herm. Müller, 'Fertilisation,' pp. 78–9; Knuth, 'Bloemenbiol. Bijdragen'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 179.)—The flowers agree in structure with those of R. Flammula, but the corolla is rarely quite regular, almost always some or all the petals are reduced, and they may even be entirely absent. The broad yellow-margined sepals therefore take over the duty of attracting insects. The nectaries are very variable in shape, as a rule they are pits devoid of covering-scales. Hermann Müller has represented various forms of nectary in the following diagram (Fig. 9).

The flowers observed by Lindman on the Dovrefjeld were at first protogynous, afterwards becoming homogamous. Their diameter was 5–22 mm. In that region flies, and a Lepidopterid, were observed as visitors.

Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) observed in individual flowers at Ruppin — though only very rarely — that certain stamens bore a papillated stigma at the tip. Pollen-grains yellow, tuberculated, very irregular, usually rounded tetrahedral, varying in size up to 43 μ in diameter.

According to Focke (Abh. nat. Ver., Bremen, xii, 1891), Ranunculus auricomus is self-fertile.

VISITORS.—In north and central Germany the following have been observed by Herm. Müller (H. M.) and myself (Kn.).—**A. Coleoptera.** 1. Meligethes, po-dvg. (Kn.). **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia radicum *L.* ♀ and ♂, particularly freq. (H. M.); 3. Lucilia caesar *L.*, po-dvg. (Kn., Kiel.); 4. Scatophaga merdaria *F.*, skg. and po-dvg. (H. M.). (*b*) *Syrphidae*: 5. Cheilosia vernalis *Fall.*, po-dvg. (H. M.); 6. Eristalis tenax *L.*, po-dvg. (Kn., Kiel); 7. Melanostoma mellina *L.*, po-dvg. (Kn., H. M.); 8. Pipizella virens *F.*, po-dvg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 9. Andrena fulvescens *Sm.* ♂, skg. (H. M.); 10. A. parvula *K.* ♀, po-dvg. (Kn., H. M.); 11. Apis mellifica *L.* ☿, po-clg. (Kn., Kiel); 12. Halictus albipes *F.* ♀, po-clg. (H. M.); 13. H. cylindricus *F.* ♀, ditto (Kn.). (*b*) *Formicidae*: 14. An ant, nect-lkg. (Sprengel, H. M.). **D. Lepidoptera.** *Tineidae*: 15. Micropteryx calthella *L.*, skg. (H. M.). **E. Thysanoptera.** 16. Thrips (Sprengel, H. M.).

Warnstorf observed numerous pollen-devouring beetles on the flowers at Ruppin. In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 4) 2 Muscidae, and a beetle have been observed as visitors.

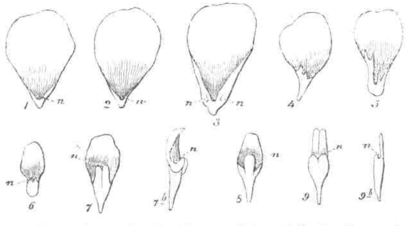

FIG. 9. *Ranunculus auricomus, L.* (after Herm. Müller). 1–8. Petals with nectaries of various forms. 9. Petals of Eranthis hiemalis, for comparison.

64. R. amoenus Ledeb.—This arctic species (Siberia, Dahuria, Spitzbergen)—which belongs to the *auricomus* group—flowers in Spitzbergen from the beginning of July until August or September, and regularly sets fruits. The bright yellow corolla has a diameter of 15–20 mm. The few stamens (6–8) are closely applied to the lower part of the gynoecium, the stigmas of which are therefore easily self-pollinated, while the upper ones are cross-pollinated by insects (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 53–4).

65. R. arcticus Richards, var. *Wilanderi* (Nath.) Freyn.—This species flowers in Spitzbergen during the middle of July and beginning of August, and sets fruits. The corolla has a diameter of 17·5–21·5 mm.

66. R. nivalis L.—This species is circumpolar. Lindman states that the flowers are first protogynous, and afterwards homogamous. The mechanism is similar to that of R. acris, but the corolla is deeper and narrower, and the floral receptacle longer and more convex. On the upper surface of each petal there are longitudinal hollow swellings. The diameter of the flower—which is 18 mm. in Arctic Siberia—is considerably less on Nova Zemlia according to Ekstam.

Andersson and Hesselman state ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 49) that it flowers and sets fruit normally in Spitzbergen. In specimens collected by Vanhöffen in Greenland (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' pp. 30–1) there were a large number of shrivelled and seedless fruits in addition to the properly developed ones. Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 23) describes the feebly fragrant flowers as 10–12 mm. in diameter; and the light or dark yellow petals as about half as long again as the sepals, which are thickly covered with dark-brown woolly hairs. He found the flowers to be protogynous-homogamous.

Visitors.—Ekstam noted one small fly in Nova Zemlia, and a large number on the flowers of one plant in Spitzbergen.

67. R. lanuginosus L. (Herm. Müller, 'Fertilisation,' p. 78, 'Weit. Beob.,' I, p. 321; Knuth, 'Bloemenbiol. Bijdragen.')—The floral mechanism agrees with that of R. acris, but—in spite of the larger flowers—insect-visits are more numerous only in the lighter parts of the woods.

Visitors.—The following have been observed by Hermann Müller (H. M.) and myself (Kn.).—**A. Coleoptera.** (*a*) *Coccinellidae*: 1. Coccinella quattuordecimpunctata *L.*, nect. skg. (H.M.). (*b*) *Dermestidae*: 2. Byturus fumatus *L.*, freq. po-dvg. (H.M.). (*c*) *Elateridae*: 3. Athous haemorrhoidalis *F.* (H. M.), with its head in the base of the flower. (*d*) *Nitidulidae*: 4. Meligethes aeneus *F.*, freq., gnawing petals and stamens (Kn., H. M.). **B. Diptera.** (*a*) *Bibionidae*: 5. Dilophus vulgaris *L.* (H. M.). (*b*) *Empidae*: 6. Empis livida *L.*, skg. (H.M.); 7. E. trigramma *Mg.*, skg. (*c*) *Muscidae*: 8. Anthomyia sp. (Kn., H. M.); 9. Hylemyia conica *Wied.* (H. M.); 10. Scatophaga stercoraria *L.* (*d*) *Syrphidae*: 11. Ascia lanceolata *Mg.*, occasional individuals (H. M.); 12. A. podagrica *F.*, freq. (H. M., Kn.); 13. Bacha elongata *F.*, occasional individuals (H. M.); 14. Cheilosia albitarsis *Mg.* (H. M.); 15. C. pubera *Zett.* (H. M.) and other sp. (H. M.); 16. Eristalis arbustorum *L.* (Kn.); 17. Melanostoma mellina *L.*, in large numbers (H. M.); 18. Pipiza notata *Mg.* (H. M.); 19. Syrphus lunulatus *Mg.* (Kn., H. M.); 20. S. nitidicollis *Mg.* (H. M.); 21. S. ribesii *L.* (Kn.); 22. S. venustus *Mg.*, in large numbers (H. M.); 23. Volucella pellucens *L.* (H. M.); all po-dvg. **C. Hymenoptera.** *Apidae*: 24. Andrena cingulata *F.* ♀, po-cltg. (H. M.); 25. A. parvula *K.* ♀, skg. (Kn., H. M.); 26. Apis mellifica *L.* ☿, po-cltg. (Kn.); 27. Bombus terrester *L.* ♀, skg. (H. M.); 28. Eriades florisomnis *L.* ♂, skg. (H. M.); 29. Halictus flavipes *F.* ♀, skg. (Kn., H. M.); 30. Osmia bicolor *Schr.* ♀, po-cltg. and skg. (H. M.).

Loew observed in the Berlin Botanic Garden.—**Hymenoptera.** *Apidae*: Eriades florisomnis, ♂ skg., ♀ po-cltg.

68. R. montanus Willd. (including R. Villarsii *DC.*). (Herm. Müller, 'Alpenblumen,' pp. 133–5.)—The flowers are about equal in size to those of the last species, and are protogynous, but automatic self-pollination is possible.

Visitors.—Loew observed in Switzerland ('Beiträge,' p. 57).—**Diptera.** (*a*) *Asilidae*: 1. Lasiopogon cinctus *F.* (*b*) *Syrphidae*: 2. Cheilosia antiqua *Mg.*, po-dvg.

Herm. Müller noticed in the Alps:—3 beetles, 20 flies, 7 Hymenoptera, and 19 Lepidoptera.

69. R. illyricus L.—

VISITORS.—Schletterer observed the following Apidae.—1. Halictus calceatus *Scop.*; and 2. H. fasciatellus *Schenck*; also 3. a saw-fly, Amsais laeta *F.*

70. R. sardous Crantz (=R. philonotis *Ehrh.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 18-20.)—The flower mechanism and circle of visitors are as in R. repens and its associated species. Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896) describes a large hairy form at Ruppin, with hollow broadly trapezoidal nectar-scales, but no secretion. Flowers slightly protogynous, anthers extrorse, ripening centripetally, and somewhat higher than the carpellary heads. Self-fertilization is therefore rendered difficult, but not wholly excluded. Pollen-grains yellow, spherical or ovoid, with three longitudinal furrows, tuberculated, 30-37 μ in diameter.

VISITORS.—H. de Vries (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875) observed — in the Netherlands—the honey-bee; and MacLeod—in Flanders—noted 2 Syrphidae, 2 Muscidae, and one of the Siricidae (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 178).

71. R. arvensis L. (Hoffmann, 'Über Sexualität'; Kirchner, 'Flora v. Stuttgart,' p. 266.)—Kirchner states that there is much variation in the size of the flowers, in the order of development, and in the number of stamens and carpels. The diameter of the sulphur-yellow flowers is 4-10 mm. When they open, the stamens are at first directed inwards above the carpels, often completely covering them, but as the anthers begin to dehisce upwardly and outwardly, the styles elongate. These are beset with stigmatic papillae at the end, and along an inwardly directed longitudinal line. Owing to the relative positions of pollen and stigmas automatic self-pollination is hardly possible. In some flowers, however, the anthers have dehisced while the stigmas are still situated below them, so as readily to catch the falling pollen. But when such blossoms reach a later stage this cannot happen, the flowers being erect, and the stigmas projecting above the anthers. The number of stamens is usually 10-13, but not infrequently some of them degenerate, so that the flower only possesses 5-2. They may even be entirely aborted, rendering the plant gynomonoecious. These female flowers are much smaller than the hermaphrodite ones, and the styles at the time of opening project from the corolla. Hoffmann also observed markedly protandrous hermaphrodite flowers. Focke states that R. arvensis is self-fertile (Abh. natw. Ver., Bremen, xii, 1893).

VISITORS.—MacLeod observed in Flanders one of the micro-Lepidoptera and 2 small Muscidae as visitors (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 180).

72. R. sceleratus L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 20, 147.)—The numerous flowers—of which the diameter is usually less than 1 cm.—make the plant conspicuous from a distance, in spite of the smallness of the individual blossoms. Consequently many short-tongued insects seek the nectar, which is secreted in a pit at the base of each petal. When the flower opens, the stamens—with anthers still unripe—lie close to the carpels, but are not so high as the already receptive stigmas. As the anthers dehisce centripetally the filaments bend away from the carpels, approaching the horizontally expanded petals. When insect visitors alight upon the carpels they effect cross-pollination, if otherwise—self-

pollination. Should insect-visits fail, the pollen of the fading anthers may reach the stigmas—which continue receptive in the oldest flowers—when the plant bends before the wind.

Visitors.—Only the following *Muscidae* were observed by me in the North Frisian islands, and at Kiel.—1. Lucilia Caesar *L.*; 2. Musca corvina *F.*; 3. various smaller species.

Verhoeff noticed the following in Norderney.—**Diptera.** (*a*) *Dolichopidae*: 1. Dolichopus aeneus *Deg.* (*b*) *Muscidae*: 2. Anthomyia sp., one ♂, skg.; 3. Aricia dispar. *Fall.* one ♂; 4. Aricia incana *Wiedem.* ♀ and ♂, po-dvg.; 5. Myospila meditabunda *F.* one ♀; 6. Scatophaga stercoraria *L.* (*c*) *Syrphidae*: 7. Eristalis intricarius *L.* one ♀; 8. Platycheirus peltatus *Mg.* one ♀; 9. Pyrophaena ocymi *F.* one ♂.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 4), flies (*Muscidae, Empidae, Dolichopidae*) have been observed.

MacLeod noticed in Flanders,—one hover-fly, and one of the Muscidae (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 179).

73. **R. Ficaria** L. (Herm. Müller, 'Fertilisation,' p. 78, 'Weit. Beob.,' I, pp. 321–2; Chatin, C-R. Acad. sci., Paris, cxviii, 1894; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' II, p. 179; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller states that the mechanism of pollination in these golden-yellow flowers—which expand in the sunshine to form a star about 20–25 mm. in diameter—agrees with those of R. acris and R. auricomus. Besides homogamous or slightly protandrous hermaphrodite flowers, there are also female ones. At the beginning of the flowering season, flowers are frequently to be found in which the number of developed petals is as low as three, or even two, but later the number increases to 8–10. The size of the flowers, and the number of stamens, commonly exhibit very considerable variation.

The flowers seldom set fruits. Irmisch and Hunger saw them in shady wet localities, while Kerner—on the contrary—observed here and there ripe heads of fruits in sunny places, while he found the plant sterile in shady spots, with bulbils in the axils of the leaves. Warnstorf states (Verh. bot. Ver., Berlin, xxxviii, 1896) that at Ruppin, where the plant grows abundantly in shady ditches under walls, fruits (usually 2–3 in a head) are common, the individuals bearing them also possessing bulbils in their leaf-axils.

Burkill (J. Bot., London, xxxv, 1897) rightly says that the extreme rarity of fruits in Ranunculus Ficaria is a puzzle. The failure to form seeds cannot be ascribed to a deficiency of insect guests, for a variety of these visit the flowers in large numbers.

Chatin asserts that the bulbil-producing form produces no seeds, because it has no pollen. Müller—on the contrary—cultivated a plant with bulbils in the leaf-axils, and it produced ripe seeds capable of germinating. But this species propagates vegetatively—in the large majority of cases—by means of the axillary bulbils. These fall off in early summer, when all the parts of the plant above the ground die down.

Visitors.—The following have been observed by Hermann Müller (H. M.) and myself (Kn.).—**A. Coleoptera.** 1. Meligethes, freq., skg., po-dvg., and gnawing the flower-leaves (H. M., Kn.). **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia radicum *L.*, very freq. (H. M.); 3. A. sp., po-dvg. (Kn.); 4. Scatophaga merdaria *F.* (H. M.); 5. Sepsis, freq. (H. M.). (*b*) *Syrphidae*: 6. Brachypalpus valgus *Pz.*, po-dvg.

(H. M.); 7. Rhingia rostrata *L.*, po-dvg. (Kn.). **C. Hymenoptera.** *Apidae*: 8. Andrena albicans *Müll.* ♀ and ♂, po-cltg. and skg. (H. M.); 9. A. gwynana *K.* ♀, po-cltg. (H. M.); 10. A. parvula *K.* ♀, skg. (H. M.); 11. Apis mellifica *L.* ☿, freq., skg. and po-dvg. (H. M., Kn.); 12. Halictus albipes *F.* ♀, skg. (H. M.); 13. H. cylindricus *F.* ♀, ditto (H. M.); 14. H. lucidus *Schenck* ♀, ditto (H. M.); 15. H. nitidiusculus *K.* ♀, ditto (H. M.); 16. H. sp., skg. (Kn.); 17. Osmia rufa *L.* ♂, skg. (Thuringia). **D. Thysanoptera.** 18. Thrips, very freq. (H. M.).

Sickmann mentions Salius sepicola *Sm.* (a fossorial wasp) as a visitor of the plant at Osnabrück.

Alfken and Höppner (H.) observed the following at Bremen.—**A. Hymenoptera.** *Apidae*: 1. Andrena albicans *Müll.* ♀ and ♂, skg.; 2. A. cineraria *L.* ♂, skg.; 3. A. clarkella *K.* ♂; 4. A. extricata *Sm.* ♀; 5. A. flavipes *Pz.* ♀ and ♂; 6. A. gwynana *K.* ♀ and ♂; 7. A. morawitzi *Ths.* ♀; 8. A. nitida *Fourcr.* ♂; 9. A. parvula *K.* ♀ and ♂; 10. A. varians *K.* ♀ and ♂; 11. Apis mellifica *L.* ☿; 12. Bombus agrorum *F.* ♀; 13. B. terrester *L.* ♀; 14. Halictus minutus *K.* ♀; 15. H. morio *F.* ♀; 16. H. nitidiusculus *K.* ♀; 17. Nomada alternata *K.* ♂; 18. N. bifida *Ths.* ♂; 19. N. borealis *Zett.* ♀ (H.); 20. N. fucata *Pz.* ♂; 21. N. lineola *Pz.* ♂; 22. N. ruficornis *L.* ♂; 23. N. xanthosticta *K.* ♀ and ♂, skg.; 24. Osmia rufa *L.* ♀; 25. Podalirius acervorum *L.* ♂. **B. Diptera.** *Syrphidae*: 26. Brachypalpus valgus *Pz.*

MacLeod noted in Flanders,—2 long-tongued bees, 2 short-tongued bees, a saw-fly (Tenthredinidae), 3 Muscidae, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 181–2).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 41) there were observed,—Apis, Syrphidae, Empidae, and Muscidae.

Burkill ('Fertilisation of Spring Flowers') observed the following on the coast of Yorkshire.—**A. Coleoptera.** (*a*) *Chrysomelidae*: 1. Longitarsus fuscicollis *Foudr.* (*b*) *Colydiidae*: 2. Coninomus nodifer *Westw.* (*c*) *Nitidulidae*: 3. Meligethes picipes *Sturm.*, freq., skg. **B. Diptera.** (*a*) *Muscidae*: 4. Onesia cognata *Mg.*, one instance, skg.; 5. Lucilia cornicina *F.*, skg. and po-dvg.; 6. Pollenia rudis *F.*, one instance; 7. Scatophaga stercoraria *L.*, freq., skg. and po-dvg.; 8. Sepsis nigripes *Mg.*, occasional, skg. and po-dvg. (*b*) *Empidae*: 9. Empis sp., one instance, skg. (*c*) *Phoridae*: 10. Phora sp. (*d*) *Syrphidae*: 11. Cheilosia nebulosa *Verral*; 12. Eristalis arbustorum *L.*, one instance, skg.; 13. E. pertinax *Scop.*, freq., skg. and po-dvg.; 14. Melanostoma quadrimaculatum *Verral*, ♀ and ♂, skg.; 15. Syrphus lasiophthalmus *Zett.*, skg. **C. Hymenoptera.** (*a*) *Apidae*: 16. Andrena clarkella *K.*, skg.; 17. A. gwynana *K.*, ♀ and ♂, occasional, skg.; 18. A. nigro-aenea *K.* ♀; 19. Apis mellifica *L.* ☿, one instance, skg. and po-cltg.; 20. Bombus agrorum *F.*, one instance. (*b*) *Formicidae*: 21. Formica fusca *L.* (*c*) *Ichneumonidae*: 22. Ichneumon sp., skg. **D. Lepidoptera.** *Rhopalocera*: 23. Vanessa urticae *L.*, skg. **E. Thysanoptera.** 24. Thrips sp.

11. Coptis Salisb.

74. Coptis trifolia Salisb.—This species is native to Greenland, Norway, Siberia, Kamchatka, and Japan, also ranging from Alaska to Labrador. There are five white sepals veined with purple, and 6 mm. long. The five or more hood-shaped orange-yellow petals are very much smaller, being only 2 mm. in length. They secrete nectar, and the stamens project beyond them. Warming states that this northern plant is homogamous in Greenland. He could not determine the presence of nectar. The flower belongs either to **C** or **Po**.

12. Caltha L.

Flowers *homogamous, with half-concealed nectar.* The large yellow sepals serve to attract insects: there are no petals. Nectar is secreted in two shallow depressions, one on either side of each ovary (Fig. 10).

75. C. palustris L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 147; Sprengel, 'Entd. Geh.,' p. 298; Herm. Müller, 'Fertilisation,' pp. 79–80; 'Weit. Beob.,' p. 322, 'Alpenblumen,' pp. 135–6; Kirchner, 'Flora v. Stuttgart,' p. 270; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Schulz, 'Beiträge,' II, p. 179; Haussknecht, Mitt. geogr. Ges., Jena, vi, 1887.)—In the large egg-yolk yellow flowers—which spread out in the sunshine to a surface 4 cm. across—nectar is so abundant that the drops from adjacent nectaries (Fig. 10) run together. Although stamens and carpels mature simultaneously, cross-pollination is favoured, for the anthers dehisce extrorsely and mature centripetally. In addition to the ordinary plants with homogamous hermaphrodite blossoms, stocks with purely male flowers have been observed in France and the Tyrol. In the Scandinavian highlands the flowers are sometimes only 2 cm. in diameter, and Lindman states that in that region they possess a slight odour, suggestive of gutta-percha. According to Ekstam, the diameter of the flowers is 10–36 mm. in Nova Zemlia. Haussknecht observes that large-flowered forms predominate in Thuringia, and small-flowered ones in South Germany. Lecoq ('Géographie botanique de l'Europe,' IV, p. 488) speaks of this species as being andromonoecious (Darwin, 'Different Forms of Flowers,' p. 13).

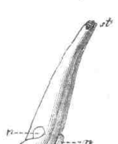

FIG. 10. *Caltha palustris, L.* (after Herm. Müller). A single carpel. *st*, stigma. *n*, nectary (with a drop of nectar).

VISITORS.—The following have been observed by Hermann Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein.—

A. **Coleoptera.** (*a*) *Chrysomelidae*: 1. Donacia discolor *Hoppe* (H. M.); 2. Hélodes marginella *L.* (H. M.). (*b*) *Curculionidae*: 3. Bruchus seminarius *L.*, nect-lkg. (?), (H. M.). (*c*) *Nitidulidae*: 4. Epuraea aestiva *L.* (H. M.); 5. Meligethes, very freq., skg. and po-dvg. (H. M.). (*d*) *Staphylinidae*: 6. Tachyporus hypnorum *F.*, nect-lkg. (?), (H. M.). **B. Diptera.** (*a*) *Bibionidae*: 7. Dilophus vulgaris *Mg.* ♀, in large numbers (H. M.). (*b*) *Empidae*: 8. Cyrtoma spuria *Fall.* (H. M.); 9. Empis opaca *F.*, skg. (H. M.). (*c*) *Muscidae*: 10. Anthomyia sp., extremely common, po-dvg. (H. M., Kn.); 11. Aricia serva *Mg.* (H. M.); 12. Hydrotaea dentipes *F.* (H. M.); 13. Onesia floralis *R.-D.* (H. M.); 14. Scatophaga merdaria *F.* (H. M.); 15. S. stercoraria *L.*, po-dvg. (H. M.). (*d*) *Stratiomyidae*: 16. Odontomyia argentata *F.* (H. M.). (*e*) *Syrphidae*: 17. Ascia podagrica *F.*, po-dvg. (H. M.); 18. Cheilosia albitarsis *Mg.*, skg. and po-dvg. (H. M.); 19. C. sp., po-dvg. (H. M.); 20. C. pubera *Zett.*, po-dvg. (H. M.). 21. Eristalis arbustorum *L.*, freq., skg. and po-dvg. (Kn., H. M.); 22. E. intricarius *L.*, skg. and po-dvg. (H. M.); 23. E. nemorum *L.*, ditto (H. M., Kn.); 24. Melanostoma ambigua *Fall.* (H. M.); 25. Pipiza tristis *Mg.* (H. M.); 26. Platycheirus manicatus *Mg.* (H. M.); 27. Rhingia rostrata *L.*, po-dvg. (H. M.). **C. Hymenoptera.** *Apidae*: 28. Andrena albicans *K.* ♂, skg. (H. M.); 29. Apis mellifica *L.* ☿, very freq., skg. and po-dvg. (H. M., Kn.); 30. Bombus terrester *L.* ♀, skg. (H. M., Kn.); 31. Osmia rufa *L.* ♂, skg. (H. M.). **D. Neuroptera.** *Perlidae*: 32. Perla sp., freq. (H. M.).

Von Fricken noticed—in Westphalia and East Prussia—the Chrysomelid Prasocuris hannoverana *F.*; Rossler—at Wiesbaden—the moth Eriocephala calthella *L.*

In the Alps, Hermann Müller observed four flies.

MacLeod noted—in Flanders—Apis, 3 hover-flies, and 4 Muscidae (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 182), and—in the Pyrenees—one of the Muscidae.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 6) there were observed—Apis, one humble-bee, hover-flies, Muscidae, and one of the micro-Lepidoptera.

Burkill ('Fertilisation of Spring Flowers') noticed the following on the coast of Yorkshire.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes picipes *Sturm*, one instance, skg. **B. Diptera.** (*a*) *Muscidae*: 2. Scatophaga stercoraria *L.*, skg. with difficulty. (*b*) *Syrphidae*: 3. Syrphus sp., one instance, po-dvg. **C. Hemiptera.** 4. Deraeocoris sp. **D. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.*, one instance, po-cltg.

13. Trollius L.

Flowers mostly homogamous with concealed nectar. The large bright yellow sepals are folded together into a sphere, and serve as the means of attraction. They enclose the small linear petals, each of which possesses an uncovered nectar-pit at its base.

76. T. europaeus L. (Herm. Müller, 'Alpenblumen,' pp. 136–7; Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Beyer, 'D. spont. Bewegungen

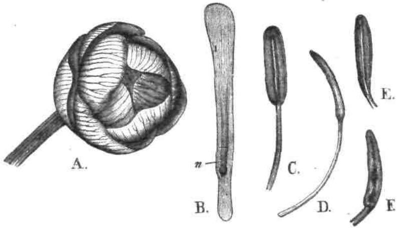

FIG. 11. *Trollius europaeus*, *L.* (after Herm. Müller). A. Flower seen from without, somewhat reduced. B. Petal with nectary (*n*) seen from within. C. Stamen, before the dehiscence of the anther, seen from within. D. The same, seen from the side. E. An anther with loculi almost empty. F. The same, seen from the side. B–F × 4⅔.

d. Staubgefässe u. Stempel'; Kerner, 'Nat. Hist. Pl.', Eng. Ed. 1, II; Kirchner, 'Flora v. Stuttgart,' p. 270; Schulz, 'Beiträge,' II, p. 8; Knuth, 'Blütenbiol. Herbstbeob.')—The flowers have a slight odour (seeming to Kerner like that of Auricula), and in dull weather are almost completely closed, though in sunshine the sepals are not so close together. The numerous stamens have curved inwards before the pollen is shed, and as the anthers dehisce centripetally, they elongate to some extent. Insects penetrating from above, to reach the pollen or nectar, first alight on the stigmas in the middle of the flower, and effect cross-pollination with tolerable constancy. Should there be no insect visitors, automatic self-pollination is inevitable, as the outer stamens project above the stigmas. It is, however, questionable if this is effective.

VISITORS.—I have observed one of the Muscidae (Anthomyia sp.) covered with pollen, and also Forficula auricularia *L.*, devouring the anthers. Hermann Müller

found in the Alps 3 beetles, 4 flies, and 3 small Hymenoptera. Ricca also saw small flies covered with pollen in the flowers. Schulz observed numerous flies, Hymenoptera, and beetles.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 6) there have been observed,—one beetle, one of the Muscidae, 3 hover-flies, and a saw-fly.

Loew observed in the Berlin Botanic Garden a bee—Halictus minutissimus *K.* ♀, po-cltg.

14. **Eranthis** Salisb.

Flowers homogamous, with half-concealed nectar. The elongated yellow sepals serve to attract insects. The nectar is secreted by the modified petals, which are converted into small, hollow nectaries, resembling inverted cones in shape, and almost bilabiate. (See Fig. 9, 9.)

77. **E. hyemalis** L. (Herm. Müller, 'Fertilisation,' pp. 80–1; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 213; Knuth, 'Bloemenbiol. Bijdragen.')—Müller states that the flower mechanism agrees with that of Ranunculus auricomus. The flowers close in dull weather, and expand in sunshine. Their stamens and carpels mature simultaneously, so that insects—which pay their visits only while the sun is shining, when they alight upon the middle of the flower—effect cross-pollination, but in cloudy weather automatic self-pollination takes place in the closed flower by contact of the anthers with the stigmas. Kerner states that the anthesis of these flowers—which remain open from eight o'clock in the morning till seven in the evening—lasts for eight days. During this time the floral leaves increase to double their original size.

Visitors.—In the Garden at Kiel, I observed the honey-bee collecting pollen and sucking nectar. Hermann Müller noticed the same insect in Westphalia 'in great numbers, sufficient to fertilize all the flowers.' He also observed 3 Muscidae;—1. Pollenia rudis *F.*, 'stroking petals, anthers, and sometimes stigmas with the end-flaps of its proboscis, but finally thrusting its proboscis into the nectaries'; 2. Musca domestica *L.*, ditto; 3. Sepsis, 'busy about the anthers.' I saw yet another visitor—Vanessa urticae *L.*—resting on the sepals, and sucking nectar, but it touched neither anthers nor stigmas.

15. **Helleborus** Adans.

Flowers protogynous, with concealed nectar. The large sepals serve to attract insects. The petals are modified into short-stalked nectaries of greenish colour, which are in the form of short tubes and more or less distinctly bilabiate.

78. **H. foetidus** L. (Kirchner, 'Flora v. Stuttgart,' p. 271; Knuth, Bot. Centralbl., Cassel, lvii, 1894.)—The ovoid flowers are green, usually spotted or bordered with brown externally, and are moderately conspicuous owing to their being associated in a crowded inflorescence. When they open, the stigmas are mature, and are so placed in the narrow entrance of the flower—only 1 cm. in diameter—that every moderately large insect that creeps in must inevitably brush against them. Each carpel possesses stigmatic papillae not only on its slightly clavate end, but also on its outer side, these being continued along a groove as

far as the anthers, which in this first (female) condition are still unripe. The carpels project 3–4 mm. beyond them. The extension of the stigmatic surfaces is an adaptation to the movement executed by nectar-seeking insects.

The filaments now elongate—in centripetal order—until the extrorsely dehiscing anthers completely fill the entrance to the flower, which is about 1·5–2 cm. wide. The carpels also increase in length by a few millimetres. At the beginning of this second (male) condition, the stigmas have not quite withered, but are still receptive, so that an insect alighting on them may still bring about cross-pollination, or the fall of pollen from the same flower may automatically effect self-pollination. Looked at with the naked eye, or with a lens, the stigmatic papillae certainly look dried up, but microscopic examination shows that at the beginning of this second stage numerous pollen-grains adhere to them. Should, however, self-pollination take place it is probably ineffective, for ripe fruits containing seeds are rarely found if insect-visits fail owing to unfavourable weather.

Nectar is secreted and concealed in remarkable cup-shaped nectaries, formed by specialization of the petals. The flowers being pendulous, and the sepals forming a close investment, the secretion is well protected from rain. The nectaries are close to the sepals, while the stamens and stigmas project so far beyond them that some of

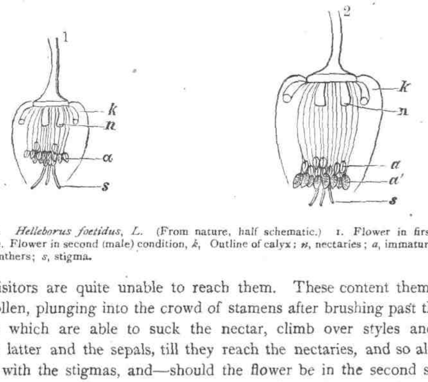

FIG. 12. *Helleborus foetidus*, *L.* (From nature, half schematic.) 1. Flower in first (female) condition. 2. Flower in second (male) condition, *k*, Outline of calyx; *n*, nectaries; *a*, immature anthers; *a'*, mature anthers; *s*, stigma.

the insect visitors are quite unable to reach them. These content themselves with gathering pollen, plunging into the crowd of stamens after brushing past the stigmas. The insects which are able to suck the nectar, climb over styles and stamens, between the latter and the sepals, till they reach the nectaries, and so always come into contact with the stigmas, and—should the flower be in the second stage—dust themselves with pollen. It therefore follows that pollen-collectors and nectar-suckers alike effect cross-pollination.

VISITORS. — These are chiefly **Hymenoptera**, of which I observed the following.—

1. Apis mellifica *L.* ☿, very freq., both po-cltg. and skg.; 2. Bombus terrester *L.* ♀, occasional, ditto; 3. B. lapidarius *L.* ♀, ditto, ditto; 4. Anthophora pilipes *F.* ♀, ditto, ditto. Also **Diptera.** 5. Eristalis tenax *L.*, po-dvg.

• **79. H. viridis** *L.* (Sprengel, 'Entd. Geh.,' p. 298; Knuth, Bot. Centralbl., Cassel, lvii, 1894.)—The yellowish-green flowers are solitary, or in pairs, and owing

to the early time of flowering, insect visitors are considerably fewer in number than in the last species.

Here again the stigmas are mature when the flower opens, and curve outwards pretty strongly. The calyx—which is at first 1·5 cm. in diameter—exceeds them in length by several millimetres, they in their turn being longer by about 5 mm. than the *as yet quite immature anthers, which project but little beyond the nectaries.*

An insect when sucking nectar is obliged to hold on by the downwardly-directed styles, and—*if* it has come from a flower in the second condition—will dust the stigmas with foreign pollen. The styles are therefore considerably stouter than in the last species, and their curvature—in correspondence with the wider opening of the flower—is greater. The tips of the styles are capitate.

The stigmatic papillae are larger than in H. foetidus. They closely cover the dilated end of the style, along the inner side of which they are continued for some distance. The pollen-grains of the two species are of about the same size (0·04 mm. long, and 0·02 mm. broad) and are of a similar elongated ovoid form. In H. viridis the stigmatic papillae are somewhat conical, so that a pollen-grain exactly fits into the space between two of them, and to a certain extent is held fast.

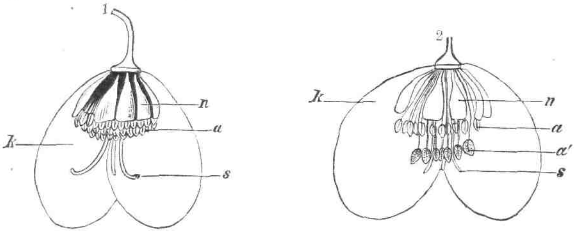

FIG. 13. *Helleborus viridis, L.* (From nature: the three front sepals have been removed.) 1. Flower in the first (female) condition. 2. Flower in the second (male) condition. *k*, sepal; *n*, nectary; *a*, immature anther; *a'*, mature anther; *s*, stigma.

As the stigmas gradually wither, the stamens elongate centripetally, turning outwards the sides which are covered with pollen to the place that the stigmas occupied in the first stage of flowering. At the same time the sepals spread out so as to increase the diameter of the flower to 3 cm.

The nectaries are considerably larger than in the last species, and—the flower being pendulous—rain is kept away from their secretion. The blossom having a much larger opening than in H. foetidus, insect visitors easily reach the nectar-cups without much searching, and suck while holding on by the styles and stamens, so that here again cross-pollination must ensue. None of the insect visitors I observed were engaged solely in gathering pollen.

VISITORS.—I observed the following in Kiel Garden.—

Hymenoptera. 1. Apis mellifica *L.*; 2. Bombus terrester *L.* ♀; 3. B. lapidorius *L.*

MacLeod noticed an Andrena in the Pyrenees, and Burkill ('Fertilisation of Spring Flowers') saw on the coast of Yorkshire,—Bombus terrester *L.*, skg.

80. H. niger L. (Knuth, Bot. Centralbl., Cassel, lvii, 1894.)—In spite of the very large white flowers insect visitors are extremely few, no doubt because the unfavourable flowering season usually deters them from flying about. The flowers in all respects agree in structure with those of H. viridis. Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896) says that the number of the nectaries is about 10–12. *The white, smooth, ellipsoidal pollen-grains average 53 μ in length, and 28 μ in breadth.*

Visitors.—I observed at Kiel only Apis mellifica *L.*

81. H. siculus Schff.—native to Etna—agrees essentially in its anthesis (Nicotra, Boll. Soc. bot. ital., Firenze, 1894) with the other species of Helleborus described by me, more particularly with H. viridis. This Sicilian species is also protogynous. The nectaries only begin to secrete when the anthers dehisce. Autogamy is completely prevented, for the stigmas have withered by the time the first anthers have shed their pollen.

82. H. atrorubens Waldst. et Kit.—

Visitors.—Loew observed—in the Berlin Botanic Garden—the honey-bee, po-cltg,, and saw it also on

83. H. cyclophyllus Boiss., and

84. H. lividescens A. Br. et Sauer, as well as on

85. H. pallidus Host, on which species in the same place he also noticed one of the Muscidae (Scatophaga stercoraria *L.*).

16. Isopyrum L.

Flowers with half-concealed nectar. The sepals serve as the chief means of attracting insects. The petals are modified into shovel-shaped nectaries, and are considerably smaller than the sepals.

86. I. thalictroides L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 120.)—Soon after the white flower has opened the anthers of the outermost staminal whorl dehisce, and at the same time the filaments bend over so as to bring them above the nectaries, in which position they must necessarily be brushed against by nectar-sucking insects. Next day these stamens move outwards towards the reflexed sepals, while simultaneously the next whorl of stamens dehisce, and bend over the nectaries. On the third day these in turn move outwards, their place being taken by the members of the third whorl, and so on in succession till all the stamens have brought their anthers above the nectaries. Insects alighting upon the middle of the flower must of necessity effect cross-pollination if they have already visited another blossom of the same species.

Visitors.—Nothing is known about these.

17. Nigella Tourn.

Markedly protandrous bee-flowers. The large brightly coloured sepals serve to attract insects. The eight petals are converted into nectaries of a characteristic kind. They possess a hollow claw, bent like a knee, and a split limb provided with

two processes. Above the angle of the claw, on its upper side, there is a slit protected by a cover. The nectar is sècreted internally on the under side of the bend, and is concealed in the cavity of the tubular claw. The cover closes by elasticity after it has been raised, and lies between two projections which prevent it from being displaced. (See Fig. 14, *B, C, D.*)

87. **N. arvensis** L. (*Sprengel, 'Entd. Geh.,' pp. 280–9; Terraciano, 'Intorno* alla strutt. fiorale ai process. d'impollinaz. in alc. Nigella,' Boll. Soc. bot. ital., Firenze, 1892, pp. 46–51; Knuth, 'Bloemenbiol. Bijdragen.')—Sprengel has given a very thorough account of the structure of the flower. The description is one of the most signal achievements of this great investigator.

The sepals are whitish below and bright blue at the tip. The small nectariform petals are brownish or blue on the upper side, with two white or yellow-green transverse bands. Their limbs present whitish or brown transverse striations: the process of the nectar-cover is whitish and brown. It is further to be noted that the white filaments are marked on the inner surface—not far from their insertion—with a white spot thát can be dimly seen by transparency on the outside. The

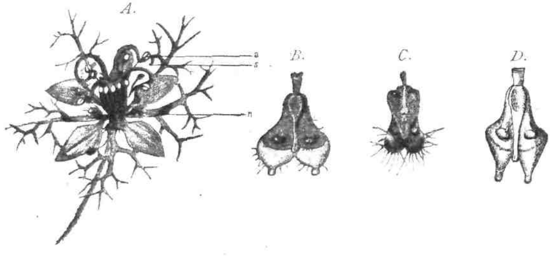

FIG. 14. *Nigella, L.* (From nature.) *A.* Nigella damascena *L.* Flower towards the end of the second stage: the styles have curved spirally downwards, and are in contact with the anthers (*a*), which are still covered with pollen, so that automatic self-pollination necessarily follows. (Natural size.) *B, C, D.* Nectaries of N. Sativa, N. damascena, and N. arvensis (× 3½). The form of the nectaries *B* and *C* appears to be somewhat variable.

flower thus possesses a series of ten alternating light and dark rings, which serve as annular nectar-guides, by which insect visitors (bees) are directed to one nectary after another.

Above the nectaries there are eight groups of stamens, each consisting of six members, one behind the other. When the flower opens all the forty-eight stamens are erect. On the first day of flowering the outermost member of each group curves downwards and outwards, which causes the dehiscing side of its anther to face downwards, so that the dorsal surface of an insect sucking from the nectaries must necessarily be dusted with pollen. On the second day the eight outermost stamens—which are now withered—assume a horizontal position, so as to lie upon the sepals, and their place is occupied by the eight stamens next in order. On

the third day these also have moved down, and are replaced by a third set of eight, and so on in succession, until in six days' time all the stamens are withered and prostrate.

Meanwhile the styles are erect, but they gradually turn over in a somewhat spiral fashion, curving outwards and downwards so as to be almost horizontal when all the anthers have withered. The stigma, which is in the form of a longitudinal seam extending from the base of the style to its tip, must now come into contact with insects engaged in sucking nectar, and will be dusted with pollen should these happen to come from a flower of the same species in the first condition. After the styles have occupied this position for three or four days, they again become erect. I observed in garden plants that automatic self-pollination sometimes took place by a spiral downward movement of the styles, in cases where insects had not brought about cross-fertilization. Terraciano states that the pollen of the lower stamens is unable to effect self-fertilization, and that automatic self-pollination usually occurs by the stigmas coming into contact with the anthers of the upper stamens. This investigator observed no insect visitors on wild plants: on the contrary, he found that this species, and also N. sativa *L.*, N. damascena *L.*, N. Bourgaei *Jord.*, N. foeniculacea *DC.*, and N. gallica *Jord.*, produced numerous seeds capable of germinating without the aid of pollinating agents, i.e. as the results of automatic self-pollination.

VISITORS.—Sprengel long ago observed bees which were precisely adapted to the dimensions of the flowers. Bees alone are clever enough to lift the nectar-covers. I have seen Apis, and also Bombus lapidarius *L.* ☿, skilfully opening the nectaries, and regularly effecting cross-pollination. I also saw Vanessa Io *L.*, as a useless flower-guest.

Friese observed in Hungary,—the silk-bee Colletes punctatus *Mocs.* ♂ not infrequent, ♀ very infrequent, and its parasite the cuckoo-bee, Epeolus fasciatus *Friese* (= E. transitorius *Friese*), not infrequent.

88. N. sativa L. (Knuth, 'Bloemenbiol. Bijdragen') agrees in the structure of its flowers with the last species, but the nectaries are slightly different.

VISITORS.—I saw in the Kiel Botanic Garden the honey-bee and 2 humble-bees (Bombus terrester *L.* ☿, and B. lapidarius *L.* ☿ and ♂) on this species and N. damascena. These opened the nectaries one after the other and sucked nectar. While doing so, the upper side of the thorax was in contact with the pollen-covered anthers, or the receptive stigmas, thus effecting crossing.

89. N. damascena L. (Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Notizen'; Herm. Müller, 'Weit. Beob.,' I, p. 322.)—The flowers agree in structure with those of the last two species. Here automatic self-pollination regularly takes place by spiral twisting downwards of the styles, and, as the flowers always set fruits, it would appear to be effective. (Cf. Fig. 14, *A*.)

VISITORS.—Vide supra, No. 88.

Buddeberg observed the two following bees in Nassau.—

• 1. Ceratina callosa *F.* ♂, busy among the stamens; 2. Prosopis confusa *Nyl.* ♂, skg.

18. **Aquilegia** *Tourn.*

Protandrous humble-bee flowers. The blossoms are rendered conspicuous by the brightly coloured sepals and petals, and the stamens and carpels project from among them like a yellow central column. Nectar is secreted and concealed at the bottom of the spurs of the petals.

90. **A. vulgaris** L. (Sprengel, 'Entd. Geh.,' pp. 279–80; Herm. Müller, 'Fertilisation,' pp. 81–2; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Schulz, 'Beiträge'; Kirchner, 'Flora v. Stuttgart.,' p. 273; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 230, 'Blütenbiol. Beob. a. d. Ins. Rügen.')—The violet-blue (rarely pink or white) flowers are pendulous, so that the nectar secreted in the ends of the spurs of the petals is protected from rain. The spurs are 15–22 mm. long, and their funnel-like openings are wide enough to readily accommodate the head of a humble-bee. The much narrower terminal part of the spur curves inwards and downwards, and conceals the nectar, which is secreted by a fleshy thickening at the extreme tip. Humble-bees—which possess a proboscis long enough to reach the nectar in the legitimate way—cling to the flowers from below, holding on to

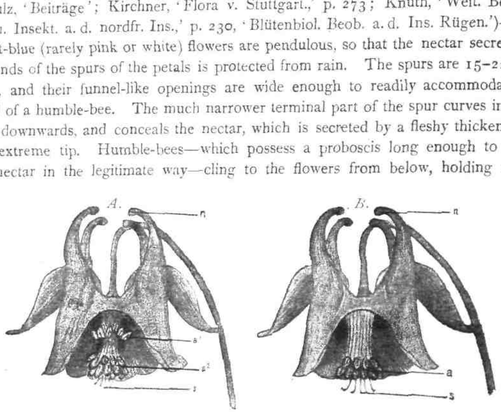

FIG. 15. *Aquilegia vulgaris, L.* (From nature: the front petal and two sepals have been removed.) *A.* Flower in the first (male) condition: most of the anthers (a^2) have already dehisced, a few of them (a^1) are still immature, with their short filaments still directed upwards. The stigmas (*s*) are still immature. *B.* Flower in the second (bisexual) condition: all the anthers (*a*) have dehisced, and the stigmas (*s*) are mature. *n*, nectary.

the base of the spur with the fore-legs, and to the stamens and carpels with the other two pairs of legs, and pushing the head into the spurs. In so doing the underside of the abdomen comes into contact—in the younger flowers—with the pollen-covered anthers, which closely surround the pistil. In older flowers the same region of the body touches the somewhat spreading stigmas which project from among the stamens, so that cross-pollination is necessarily effected. Should insect-visits fail, automatic self-pollination readily takes place, for the carpels grow down in the middle of the stamens, and by elongation of the styles the stigmas ultimately reach a lower level than the anthers.

VISITORS.—The usual pollinator is the garden humble-bee (Bombus hortorum *L.*), the long (19–21 mm.) proboscis of which easily reaches to the tip of the spur. It is the most frequent visitor of the columbine: I observed it in Schleswig-Holstein, Mecklenburg, Thuringia, North Pomerania, Rügen, the North Frisian islands, and

elsewhere, while Hermann Müller noticed it in Westphalia. He also saw—but much more rarely—the field humble-bee (Bombus agrorum *F.* ♀) sucking nectar in the legitimate way, and effecting crossing. This bee, however, in order to enable its somewhat shorter (12–17 mm.) proboscis to reach the nectar, must have thrust its head right into the opening of the spur, so as to diminish the distance to be traversed by about 5 mm. Bees with a still shorter proboscis are excluded from legitimate enjoyment of the nectar, and they must bite through the spur to get at it. Bombus terrester *L.*—the proboscis of which is only 7–3 mm. long—is particularly addicted to biting through the bend of spur and stealing nectar through the hole. Hermann Müller saw one of these bees settle upon the upper side of a columbine flower, lick the bases of the sepals, and on finding nothing there, creep to the lower surface and thrust its head into the spur. Still finding nothing, it once more crept to the upper surface, again vainly licked the bases of the sepals, and finally bit through the spur, thrust the tip of its proboscis into the hole, and thus secured the nectar. It subsequently robbed the remaining spurs of the same flower, and those of other flowers, without further deliberation, and it is probable that every member of the species has to learn by experiment how to get at the nectar. But, after having acquired the knowledge, it perforates the spurs even of unopened flowers, thus stealing a march on legitimate visitors, as H. Müller observed at Lippstadt, and I myself at Kiel. Sprengel noticed that the honey-bee (with a proboscis 6–7 mm. long) behaved in the same way as B. terrester. Hermann Müller confirms this, and adds that it also often uses the perforations made by B. terrester. The holes bitten out by humble-bees when stealing nectar were also observed by Schulz in the Tyrol and in Thuringia.

Both honey-bees and some of their smaller allies—among which Hermann Müller noted Halictus smeathmanellus *K.* ♀ and H. leucozonius *Schr.* ♀—collect pollen upon columbine flowers, and in doing so may effect either cross- or self-pollination.

Visitors.—Schenck observed the following in Nassau.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena convexiuscula *K.*; 2. A. curvungula *Thoms.*; 3. Halictus xanthopus *K.* (*b*) *Vespidae*: 4. Odynerus melanocephalus *L.*

MacLeod noticed three humble-bees in the Pyrenees, of which only Bombus hortorum *L.* was skg. legitimately ('Pyreneeënbl.,' p. 386).

91. **A. atrata** Koch. (Herm. Müller, 'Alpenblumen,' p. 137.)—The flowers essentially agree with those of the last species. It is, however, doubtful whether automatic self-pollination occurs should insect-visits fail.

Visitors.—Herm. Müller observed three humble-bees, and two bees (species of Andrena).

92. **A. pyrenaica** DC. (MacLeod, 'Pyreneeënbl.,' pp. 385–6.)—The flowers are darker than those of A. vulgaris, with which they agree in other respects. The narrow spur of the petals is 20 mm. long, but 5–6 mm. broad at the entrance, so that a proboscis about 15 mm. long is able to reach to the tip.

Visitors.—MacLeod observed none.

93. **A. chrysantha** A. Gray. (Knuth, 'Bloemenbiol. Bijdragen.')—This species is indigenous to North America, and is a garden plant in West Europe. It possesses flowers agreeing essentially with those of A. vulgaris, but the spur is

45–50 mm. in length, so that the proboscis (20 mm. long) of Bombus hortorum *L.*—which I have repeatedly observed as a visitor—can reach only part of the nectar that often accumulates in the spur to the depth of 30 mm., or more. The length of the spur, and the pale colour of the blossoms, suggest that we have here to do with hawk-moth flowers, but I have not observed any Sphingids as visitors at Kiel.

19. **Actaea** L.

Small protogynous pollen flowers, arranged in racemes. The whitish sepals, petals, and stamens of the individual flowers serve to attract insects.

94. **A. spicata** L. (Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Delpino, 'Ult. oss.,' II: Herm. Müller, 'Weit. Beob.,' I, p. 323; Kirchner, 'Beiträge,' p. 18.)—According to Ricca, Kerner, and Kirchner, the flowers are protogynous. The ovaries are greenish, but otherwise the flowers are almost completely white, except that the sepals have violet tips, and the filaments are also in some instances of a pale violet hue. The stamens are spreading, and their ends clavate.

Visitors.—Buddeberg observed—in Nassau—a beetle (Byturus fumatus *F.*) and an earwig (Forficula auricularia *L.*), the latter devouring pollen and apparently the anthers as well.

20. **Cimicifuga** L.

Flowers with half-concealed nectar, secreted at the bases of the petals in cup-shaped pits.

95. **C. foetida** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 202.)—The small whitish flowers are in long racemes, and smell like new honey. They possess shovel-shaped nectaries. This is all that is known about the flower-mechanism, and information regarding visitors is entirely lacking.

21. **Delphinium** Tourn.

Protandrous humble-bee flowers. The nectar is secreted in the ends of one or two spurs, belonging to the two upper petals, and is concealed so deeply that it can only be reached by humble-bees with a long proboscis. The sepals serve as the chief means of attracting insects. The upper one is spurred, and its spur ensheathes those of the petals.

96. **D. elatum** L. (Herm. Müller, 'Fertilisation,' pp. 83–5, 'Weit. Beob.,' p. 322; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Schulz, 'Beiträge,' II, p. 204; Knuth, 'Bloemenbiol. Bijdragen.')—As Hermann Müller has explained in a masterly fashion, the spur of the sepal not only serves to protect the nectar, but also compels the humble-bees that alight in search of nectar to do so in the only way that effects pollination. The hollow, sharply conical end of the posterior process of each upper petal secretes nectar, getting so full of it that some enters the semi-conical cavity of this process, which is open on its inner side. As the two spurs are closely apposed, they together form a hollow cone, splitting at the end into two horns filled with nectar. The proboscis of a humble-bee—if long

enough—is thus unfailingly guided, while, at the same time, the length of the cone denies access to shorter-tongued insects. The forwardly directed parts of the same petals prolong the upper part of the hollow cone to the front, and as they expand and turn up anteriorly, they afford a convenient approach to the proboscis of a humble-bee, and also direct it with certainty to the nectar receptacle. These anterior parts of the upper petals separate on slight pressure, so that the head of a humble-bee can be entirely thrust between them, thus diminishing the distance to the nectar by 6 to 7 mm. The length of the hollow cone from its entrance to the beginning of the nectar-bearing horns is about 20 mm., and to the ends of the latter 26–28 mm., so that when the head of a humble-bee is thrust into the aperture, its proboscis must be 13–14 mm. long in order to reach the nectar, and 19–22 mm. long to empty the receptacle.

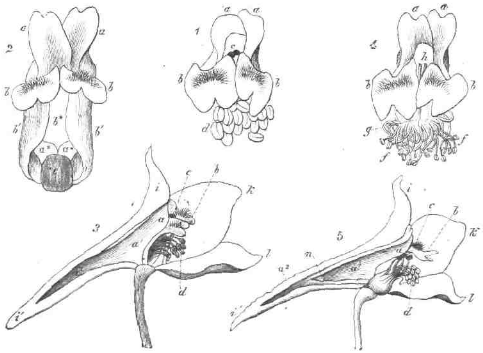

FIG. 16. *Delphinium elatum*, *L.* (after Herm. Müller). 1. Young flower after removal of the petaloid calyx; front view. 2. The petals in their natural position, seen obliquely from in front and below. 3. Young flower, after removal of the right side of the calyx, seen from the right side. 4. Older flower, after removal of the calyx, front view. 5. Young flower, after removal of the right side of the calyx and corolla, seen from the right side. *a a*, The two upper petals, which are prolonged backwards into two spurs (a^1 a^2) that secrete and contain nectar (*n*), and which in front form an entrance for the humble-bee's proboscis; a^* a^*, bases of the same; *b b*, the two lower petals, of which the closely apposed surfaces form the lower boundary of the entrance for the humble-bee's proboscis: the upper surface of each bears a tuft of yellow hairs to serve as a nectar-guide, while between their claws (2. b' b') is an interval (2. b^*) in which the anthers and stigmas successively appear (in the two stages of flowering), and which is in the path of the insect's proboscis; *c*, dehisced anthers placed behind the entrance to the spur in the path of the insect's proboscis; *d*, anthers which have not yet dehisced, and are bent downwards over the female organs; *e*, surface of attachment of the stamens and carpels (which have been removed); *f*, withered stamens bent downwards; *g*, ovaries; *h*, stigmas, which have placed themselves in the same spot that the ripe anthers occupied in the first stage; *i*, left half of the upper sepal, prolonged backwards into a corrugated sheath (i')* for the spur; *k*, left lateral sepal; *l*, left lower sepal. (3 and 5 natural size; 1, 2, and 4 enlarged.)

There are bundles of erect yellow hairs upon the front surfaces of the two lower petals—serving as nectar-guides—which are here closely apposed, thus bounding below the way of entry to the nectar, and obliging humble-bees to probe in the only right place. The claws of these petals, on the other hand, are sufficiently far apart to enable the stamens and—after they have withered and bent back—the carpels to

erect themselves in that part of the hollow cone lying immediately behind its entrance. Here they inevitably come into contact with the under-surface of the proboscis or head of a humble-bee engaged in sucking, so that cross-pollination is effected.

The stamens in their first immature condition are directed downwards, and become erect as their anthers dehisce, thus putting themselves in the way of the head of any humble-bee that may be sucking nectar. They bend down again after withering, so as to make room for the styles, which are now turning up, and carrying with them the newly-matured stigmas. Automatic self-pollination is thus excluded, and cross-pollination is necessary for fertilization. Darwin states that artificial self-pollination is ineffective.

VISITORS.—Only humble-bees with a proboscis 19–22 mm. long can suck out all the nectar in the legitimate way as described. Of the bees native to Central and North Germany, there are but two with such a proboscis, i. e. Anthophora pilipes *F.* (= Podalirius acervorum *L.*) and Bombus hortorum *L.* The former of these, however, is no longer on the wing when Delphinium elatum comes into flower, so that the garden humble-bee alone remains as the regular pollinator of this larkspur. As a matter of fact, Hermann Müller and myself—making observations in the Lippstadt and Kiel Gardens respectively—have seen hardly any other insect visitor to Delphinium elatum sucking nectar in the legitimate way, and consequently effecting cross-pollination. Some of our other native humble-bees, however, possess a proboscis long enough to reach at least some of the nectar, e. g. B. agrorum *F.* (proboscis 10–15 mm. long), and B. senilis *Sm.* (proboscis 14–15 mm. long). Hermann Müller also observed Anthophora personata *Ill.* ♀, visiting the flowers at Strassburg. In the Riesengebirge, Schulz noticed holes in the spurs that had no doubt been made by thieving short-tongued bees.

97. D. **Staphisagria** L.—Hildebrand states that this agrees in the main with the last species as regards both structure and visitors.

98. D. **Consolida** L. (Herm. Müller, 'Fertilisation,' pp. 85–6, 'Weit. Beob.,' I, p. 322; Kirchner, 'Flora v. Stuttgart,' p. 274; Schulz, 'Beiträge,' II, p. 204; Knuth, 'Blütenbiol. Herbstbeob.,' 'Weit. Beob.,' p. 231.)—As first explained by Hermann Müller, the flowers of this species chiefly differ in structure from those of the preceding in the union of the four petals. The posterior prolongations of the upper petals are fused into a single spur 15 mm. long, which secretes and conceals nectar in its end. The anterior lobes of the four petals form in addition a tube 7 mm. wide at its commencement, which readily admits the head of a humble-bee. As it is only open below, the pollen comes into contact with the under-side of a humble-bee's head at the beginning of anthesis, while the stigmas do so later, for stamens and carpels develop in the same order as in the case of D. elatum. Cross-pollination is consequently secured in D. consolida when its nectar is sucked legitimately. Automatic self-pollination is excluded: artificial self-pollination is only moderately effective.

A proboscis 15 mm. long would be able to reach the tip of the spur, which is 15 mm. in length—exclusive of the entrance, that measures 7 mm.

VISITORS.—Among the humble-bees native to Central and North Germany, there are—once more neglecting Anthophora pilipes *F.* with a proboscis 19–21 mm. long,

but which is no longer on the wing when the field larkspur comes into flower—a number of species with a proboscis 15 mm. in length (cf. vol. I, p. 160), but Bombus hortorum *L.*—with a proboscis 17–21 mm. long—is alone able to reach the nectar without considerable loss of time, the other species being compelled to force their heads between the four petal-lobes that form the entrance. Wherever observations have been made on the guests of Delphinium consolida (Westphalia, Thuringia, Schleswig-Holstein), this humble-bee has been shown to be the normal visitor and pollinator. It flies with the greatest industry from flower to flower, steadily effecting cross-pollination, and receiving all the nectar in return. Occasionally, indeed, other guests appear, especially Lepidoptera (species of Vanessa, Pieris, Satyrus, Hesperia), which usually reach the nectar with their long thin proboscis without touching stamens or carpels. I sometimes saw the honey-bee—the proboscis of which is only 5–7 mm. long—visiting the flowers and vainly seeking for nectar, thrusting its proboscis into the spur, and therefore now and then effecting cross-pollination. In Thuringia, Schulz observed spurs perforated by nectar-thieves, no doubt short-tongued humble-bees, though he was not able to catch the plunderers in the act. In the same part of Germany, Hermann Müller also noticed B. lapidarius *L.* sucking. Schletterer—at Pola—saw the bee Anthidium manicatum *L.* as a visitor.

99. **D. Ajacis** L. (Sprengel, 'Entd. Geh.,' pp. 277–8; Knuth, 'Blütenbiol. Herbstbeob.')—The flowers agree in structure with those of the last species. The length of the spur in garden plants at Kiel was 15–18 mm.

Visitors.—As a regular visitor and pollinator, I observed Bombus hortorum *L.*, and as an occasional visitor the honey-bee, which of course did not succeed in reaching the nectar. As a nectar-thief, I now and then noticed Vanessa Io. *L.*

100. **D. grandiflorum** Jord.—Jordan states that the anthers of the posterior stamens are directed forwards, while those of lateral and anterior stamens are directed laterally outwards.

22. **Aconitum** Tourn.

Literature.—Kronfeld, M., 'Über d. biol. Verhältn. d. Aconitumblüte,' Bot. Jahrb., Leipzig, xi, 1889; Abstract in Bot. Centralbl., Cassel, xxxvi, 1888, p. 392.

Protandrous humble-bee flowers. The large sepals are blue, violet, vivid yellow, or brightly mottled, and in conjunction with the smaller petals serve to attract insects. Conspicuousness is enhanced by the aggregation of the flowers into racemes, which usually bear numerous blossoms. The two upper petals are converted into long-stalked hood-shaped nectaries, covered by the upper sepal, which is galeate.

M. Kronfeld describes the stalk of the nectary of Aconitum as a hollow splint, into which nectar-sucking humble-bees insert their proboscis, this being thrust forwards and upwards to reach the actual source of the nectar.

As Kronfeld points out, the nectary is specialized to a varying extent in different species (see Fig. 17). The simplest form occurs in A. heterophyllum *Wall.*, an East Indian form in which there is a tolerably thick stalk, expanding into a cap open

below, with only a short lip on its free margin. In A. palmatum *Wall.* the spur makes its first appearance as a slight projection; in A. Napellus *L.* the lip is elongated and expanded; in A. Anthora *L.* and A. columbinum *Nutt.* the spur is more prominent, and in A. paniculatum *Lam.* it is well defined. The spur of the Japanese species A. Fischeri *Reichenb.* is prolonged and curved inwards like a flamingo's bill; in A. septentrionale *Koelle* it is drawn out in the shape of a proboscis to a length of 6 mm.; and lastly, in A. Lycoctonum *L.*, it is coiled into a spiral of $1\frac{1}{2}$ turns.

The blossoms of Aconitum are—as Kronfeld expresses it—'humble-bee flowers *par excellence*.' The body of a humble-bee exactly fills the interior of the flower, and if a plaster cast of this be made it will be found to correspond in a remarkable way to the shape of a medium-sized female humble-bee. As a matter of fact, Aconitum is dependent on Bombus, and must become extinct in places where humble-bee visits

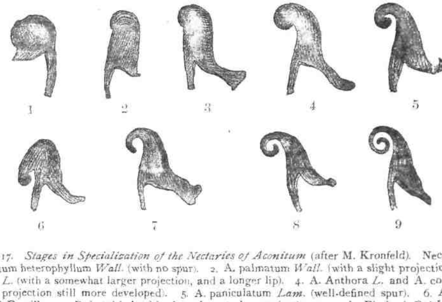

FIG. 17. *Stages in Specialization of the Nectaries of Aconitum* (after M. Kronfeld). Nectary of:—1. Aconitum heterophyllum *Wall.* (with no spur). 2. A. palmatum *Wall.* (with a slight projection). 3. A. Napellus *L.* (with a somewhat larger projection, and a longer lip). 4. A. Anthora *L.* and A. columbinum *L.* (with projection still more developed). 5. A. paniculatum *Lam.* (well-defined spur). 6. A. volubile *Pall.* and E. villosum *Rgl.* (with buckle-shaped posterior projection. 7. A. Fischeri *Reichenb.* (spur curved inwards). 8. A. septentrionale *Koelle* (spur rolled inwards). 9. A. Lycoctonum *L.* (spur rolled inwards to a greater extent).

fail, or where these insects merely rob the flowers by making lateral perforations. The dependence of monkshoods on humble-bees is best made clear by comparing their respective areas of distribution. A glance at the accompanying map (Fig. 18) will show that the area of distribution of Aconitum is entirely included in that of Bombus, while the two are coincident in the head quarters of the genera. In other words, the range of monkshoods is closely related to that of humble-bees.

101. **A. Napellus** *L.* (Sprengel, 'Entd. Geh.,' pp. 278–9; Herm. Müller, 'Alpenblumen,' pp. 137–9; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen,' and other works.)—The large upper sepal of the erect flower not only helps to attract insects, but also roofs over and protects the underlying nectaries, stamens, and carpels. The three smaller lower sepals, together with the two lower petals, take part in the work of attraction; and besides this they serve as alighting-places and platforms for the humble-bees that creep into the flower, and complete the protective investment of the stamens and carpels. The two upper petals are converted into characteristic nectaries, each with

a stalk about 15 mm. long, which follows the curve of the upper sepal, and then gradually expands into a receptacle that is open below and provided with tapering mouth-lobes, while its upper end is closed and dilated. The dilatation is bluish-black externally, greenish internally, and its inner surface secretes so abundantly that a large drop of nectar hangs in the narrowed neck of the receptacle.

The numerous stamens lie at first in the entrance to the flower with their immature anthers directed downwards. They then become erect as the anthers dehisce, and are so placed that the pollen must dust the ventral surfaces of humble-bees sucking nectar. During this first stage the 3–5 carpels are immature, and are so closely surrounded by the stamens as to be completely covered. As the

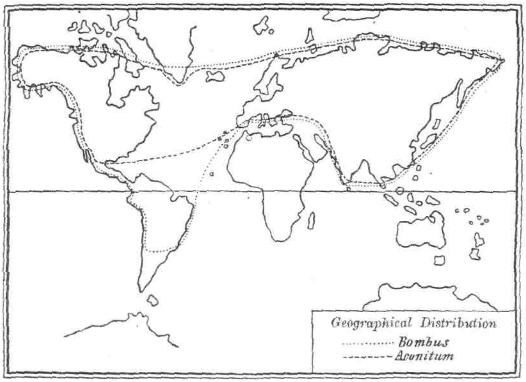

FIG. 18. *Map showing the distribution of the genera Aconitum and Bombus* (after Kronfeld).

stamens wither they bend downwards again, so that at the end of the first stage the anthers of the anterior stamens are directed backwards, those of the lateral stamens inwards, and those of the posterior stamens chiefly sideways. When all the stamens have withered the stigmas become mature, and being now free from their staminal investment occupy the entrance to the flower, so that humble-bees dusted with pollen from a blossom in the first stage, necessarily touch the stigmas and thus effect cross-pollination. Automatic self-pollination is thus normally excluded, but it sometimes happens that one or two pollen-covered stamens have not bent down again towards the base of the flower when the stigmas have matured, and in such exceptional cases self-pollination may take place.

VISITORS.—Those which act as pollinators are exclusively humble-bees. Wherever I have observed this plant in gardens (Kiel, North Frisian Islands, Mecklenburg, Rügen, Thuringia, and elsewhere), I have seen the garden humble-bee

(Bombus hortorum *L.*) sucking, and occasionally the ground humble-bee (Bombus terrester *L.*). Hermann Müller—in the Alps—saw various humble-bees sucking nectar or collecting pollen, and one of them (Bombus mastrucatus *Gerst.*) biting through the upper sepal and stealing nectar, though some individuals sucked it in the legitimate way. *In the same region he also noticed one of the Lepidoptera (Lycaena sp.) vainly trying to get at the nectar.*

Frey-Gessner observed the following bees in Switzerland.—

1. Bombus agrorum *F.* ♀, ☿, and ♂; 2. B. alticola *Kriechb.* ☿ and ♂; 3. B. brevigena *Ths.* (= B. mastrucatus *Gerst.*); 4. B. Gerstäckeri *Mor.* ♀, ☿, and ♂ (especially foundress-queens); 5. B. hortorum *L.* ♀ (which had deserted the nest), ☿, and ♂; 6. B. mendax *Gerst.* one ♀, many ☿, one ♂; 7. B. pratorum *L.*

Dalla-Torre noticed B. alticola *Kriechb.* in the Tyrol, and Schletterer B. hortorum *L.* in the same region.

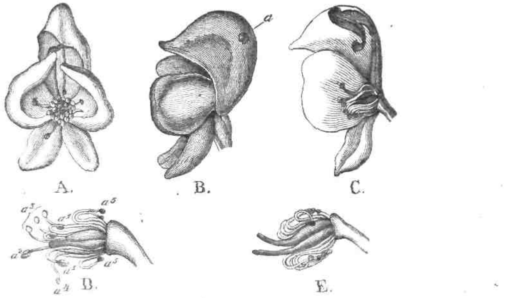

FIG. 10. *Aconitum Napellus, L.* (after Herm. Müller). A. Flower in first (male) stage. The dark-coloured stamens have become erect; their anthers have dehisced, and are coated with white pollen. B. The same flower seen from the side; *a*, a hole bitten by Bombus mastrucatus. C. The same in longitudinal section. D. Stamens and carpels in the first (male) stage: some of the anthers are mature, the stigmas are still immature; a^1, undehisced anthers with filaments bent back; a^2, stamens that are becoming erect; a^3, stamens that are erect and covered with pollen; a^4, stamens with empty anthers bending backwards; a^5, ditto, completely bent back. E. Stamens and carpels in the second (female) stage: the anthers are all empty, and the stamens bent back: the stigmas are mature. (A–C natural size: D and E × 2.)

Gerstäcker observed the following humble-bees at Kreuth.—

1. Bombus hortorum *L.*, 'frequently biting off [the flowers] at their bases, like other species of humble-bee'; 2. B. Gerstäckeri *Mor.*; 3. B. mastrucatus *Gerst.*, ♀ and ☿, 'biting off [the flowers] at their bases'; 4. Psithyrus globosus *Ev.*

Alfken saw the following humble-bees at Bremen.—

1. Bombus agrorum *F.*; 2. B. hortorum *L.*; 3. B. sylvarum *L.* And on the Schlern in the Tyrol—4. B. Gerstäckeri *Mor.*

MacLeod observed in the Pyrenees three humble-bees, and the humming-bird hawk-moth (Macroglossa stellatarum), ('Pyreneënbl.,' pp. 381–2).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 7) a humble-bee was noticed.

Kronfeld states that Handlirsch observed eight species of humble-bee in lower Austria, and Hoffer ten in upper Austria, those with a short proboscis (B. mastrucatus, B. terrester, B. soroënsis, and B. mendax) obtaining the nectar by perforating the flowers.

102. A. variegatum L.—

VISITORS.—Kronfeld—in Austria—saw Bombus agrorum (☿ and ♀) and B. hortorum (♀, ☿, and ♂) sucking legitimately, also Halictus morio and other short-tongued insects vainly seeking for nectar. Schulz observed perforated flowers of this species in Thuringia.

103. A. Lycoctonum L. (Sprengel, 'Entd. Geh.,' p. 279; Herm. Müller, 'Alpenblumen,' pp. 139–40; MacLeod, 'Pyreneënbl.'; Aurivillius, C., 'Über d. Bl. u. Befrucht. v. Aconitum Lycoctonum L.,' Bot. Centralbl., Cassel, xxix, 1887, pp. 125–8; Kronfeld, 'Über d. biol. Verhältn. d. Aconitumblüte,' Bot. Jahrb., Leipzig, xi, 1889; Loew, 'Blumenbesuch,' I, p. 28; Knuth, 'Blütenbesucher').—This agrees essentially with the species already described in the structure of its flowers, but the nectar is so deeply placed as to be only accessible to humble-bees with a very long proboscis. The upper sepal of the yellow blossom is an almost vertical cylinder, which serves as a protective envelope for the nectaries. Each of these is produced into a spiral tube (of one and a half turns), which is full of nectar, that is here secreted very abundantly. The stalk of the nectary is about 20 mm. long, and a proboscis of about the same length is necessary for sucking, as humble-bees can get no foothold in the cylindrical sepal, but are obliged to cling to the stamens and carpels.

FIG. 20. *Aconitum Lycoctonum*, *L.* (after Herm. Müller). A. Flower in the second (female) condition; seen from the side. Natural size. B. Longitudinal section of the same (nearly twice natural size). The upper stamens have already fallen off.

VISITORS.—In Central and North Germany the yellow monkshood is visited exclusively by Bombus hortorum *L.*; in the Alps almost solely by B. opulentus *Gerst.* (=B. Gerstäckeri *Mor.*)[1]. These two humble-bees have a longer proboscis

[1] Frey-Gessner ('Exkursionen im Sommer 1889,' Mitt. Schweiz. Ent. Ges., vi, 1881) first pointed out that the old ♀ of Bombus Gerstäckeri *Mor.* consistently alights upon Aconitum Lycoctonum *L.*, the ☿ and ♂ upon A. Napellus *L.*, and this phenomenon has been described by Dalla Torre as *heterotrophy* (cf. vol. I, pp. 160–1). This investigator explains the adaptation as due to the extremely short working period of this humble-bee, which only appears in July, and of course disappears at the end of September or beginning of October, and to the fact that ☿ and ♂ appear simultaneously with the foundress-queens (from Aug. 20 on), so that it is in the interest of the species that they should visit different flowers. The term 'heterotrophy' (ἕτερος, different; τροφή, food) is reasonable in so far that in districts where A. Lycoctonum and A. Napellus occur side by side in great profusion, the ♀ of B. Gerstäckeri appears actually only to visit A. Lycoctonum, the ☿ and ♂ on the other hand only

than allied species native to the regions mentioned: that of B. hortorum is 21 mm. long, and that of B. Gerstäckeri 22 mm. Alfken tells me—in a private letter—that, when ascending the Schlern in the Tyrol, he noticed large numbers of B. hortorum *L.* (♀ and ☿) with B. Gerstäckeri *Mor.* (♀) on the flowers of A. Lycoctonum, diligently sucking nectar.

In Jämtland (Sweden), Aurivillius observed B. hortorum *L.*, and frequently B. consobrinus *Dahlb.* as well. The latter resembles the former so closely that Schmiedeknecht describes it as a variety of this ('Apidae Europ.,' pp. 295, 297, 305).

MacLeod—in the Pyrenees—also met with B. hortorum *L.* as a visitor of A. Lycoctonum *L.*, var. pyrenaicum *Ser.* (=A. pyrenaicum). The same observer further noticed many individuals of B. Gerstäckeri *Mor.* ♀, sucking nectar from this flower, and effecting cross-pollination.

From these observations it appears that A. Lycoctonum *L.* is everywhere visited and pollinated by humble-bees with a proboscis of exceptional length. In the Alps and Pyrenees, however, B. mastrucatus *Gerst.* has been observed on the flowers either collecting pollen, or perforating the upper sepal at the level of the nectary, in order to steal nectar. Both in Central Germany and in Sweden, short-tongued humble-bees have been observed as nectar-thieves, e. g. B. terrester *L.* and B. alticola *Kriechb.* In Sweden, B. jonellus *K.* (=B. scrimshiranus *K.*) has been seen collecting pollen.

Aurivillius and MacLeod observed (in Sweden and the Pyrenees respectively) two very well-marked kinds of flower, between which transitional forms were found here and there. They may be described as:—

(*a*) orthocera *Knuth*: spur almost straight, relatively stout, with blunter tip;

(*b*) campylocera *Knuth*: spur more or less distinctly curved upwards—sometimes into almost a semicircle—relatively slender, tapering towards the tip. In the bud the spur of this form also is straight.

104. **A. anthora** L. (MacLeod, 'Pyreneënbl.')—The pale yellow flowers open wide. The upper sepal is produced above the mouth of the flower into a forwardly curved beak. The two lateral sepals are concave internally and clothed with woolly hairs. The two or three other floral leaves serve as alighting-places and platforms for insects. The black stamens are sharply defined against the otherwise uniform colour of the flower, which is thus made very conspicuous. The stamens and carpels develop in the same order as in A. Napellus. But few stamens mature simultaneously, so that the flower remains for a long time in the male condition.

Visitors.—None were observed by MacLeod. Hoffer noticed—at Graz—Bombus Gerstäckeri ☿, sucking.

105. **A. septentrionale** Koell.—Axell states ('Om anord. f. fanerog. växt. befrukt.,' Stockholm, 1869, p. 34) that this species also is protandrous.

A. Napellus—at least so far as observations have been made—and there is thus, at least apparently, a real difference as to diet (according to Hoffer, Natw. Miscell., 1889, pp. 21–2). Hoffer (op. cit., pp. 23–5) noticed in Steiermark, however, that in places where A. Napellus is very common, while A. Lycoctonum is exceedingly rare, B. Gerstäckeri ♀ also visits A. Napellus, so that the heterotrophy observed by Dalla Torre on the Schlern in the Tyrol does not there exist; all castes (♀, ☿, and ♂) feeding chiefly on A. Napellus.

106. **A. Cammarum** L. (=A. Stoerkianum *Reichb.*).—

Visitors.—Schneider (Mus. Aarsh., Tromsø, 1894) observed Bombus hortorum visiting this flower in the gardens of Arctic Norway, but saw it nowhere else in that region.

23. Paeonia Tourn.

Protogynous pollen flowers (?). The large red petals serve to attract insects.

107. **P. officinalis** L.—Kerner states that the flowers, which are open only in the day-time, possess the odour of nightshade.

Visitors.—I observed Bombus terrester L. ☿ in the Kiel Garden, vainly seeking for nectar.

108. **P. Moutan** Sims (=P. arborea *Don.*).—

Visitors.—Delpino says that this species, indigenous to China, is regularly pollinated by beetles (Cetoniae), which lick the fleshy disks on the bases of the ovaries.

II. ORDER *CALYCANTHACEAE* LINDL.

24. Chimonanthus Lindl.

109. **C. fragrans** Lindl. (=Calycanthus praecox *L.*).—The greenish-white strongly odorous flowers appear before the leaves, and, according to Hildebrand (Bot. Ztg., Leipzig, xxvii, 1869), are protogynous. In the first condition the still immature anthers are remote from the stigmas, and these may be pollinated by insects coming from other flowers in the second stage. In this second stage the dehisced anthers project beyond the stigmas, so that insect visitors are obliged to touch them.

The flowers are also described as protogynous by Entleutner ('Die sommergrünen Ziergehölze von Süd-Tirol,' Meran, 1892), who says that in the first stage of anthesis the unripe stamens of the newly opened flower form a funnel from the middle of which the carpels project, their stigmas being already mature. In the second stage the anthers—which so far have been curved outwards towards the perianth—apply themselves to and cover the carpels, projecting well beyond them. The anthers now dehisce, and insect visitors have to push between them and the perianth in order to get at the nectar secreted in the base of the flower. If such an insect next alights upon a flower in the first stage, it necessarily effects pollination, for the only way to the nectar is through the conical space between anthers and stigmas.

Visitors.—Delpino observed ('Altri app. dicog. recent. oss.,' Nuovo Giorn. bot. ital., Firenze, ii, 1870, p. 59) a bee (Osmia) at Florence.

25. Calycanthus L.

110. **C. floridus** L.—The brown nectarless flowers of this shrub—a native of north-east America—exhale a slight odour of strawberries. Delpino states ('Ult. oss.,' Atti Soc. ital. sc. nat., Milano, xvii, 1874, and 'Altri app. dicog. recent. oss.,' Nuovo Giorn. bot. ital., Firenze, ii, 1870, p. 58) that they are protogynous, with stigmas that soon wither.

Visitors.—Beetles (Cetoniae) appear to effect pollination.

III. ORDER *MAGNOLIACEAE* DC.

26. Illicium L.

111. **I. religiosum** L.—According to Delpino ('Applicaz. d. teor. Darwin ai fiori ed agli insetti visit. d. fiori,' *Boll. Soc. Entom.*, Firenze, ii, 1870, p. 10), there are small juicy glands like stigmatic papillae in the middle of the flower that probably serve to attract beetles (Cetoniae), which while licking nectar effect pollination.

27. Magnolia L.

112. **M. Yulan** Desf.—This species is a native of China. The erect white lily-like blossoms are odorous, and—according to Delpino ('Ult. Oss.,' Atti Soc. ital. sc. nat., Milano), they are protogynous bee flowers. In the first (female) stage of anthesis, the bees that visit them are not able to climb up the smooth petals, nor to free themselves from the short erect carpels occupying the middle of the flower, and therefore remain prisoners till the second (male) stage, in which the anthers dehisce. They are then able to leave the flower, and being dusted with pollen, may transfer this to the stigmas of another flower which is still in the first stage.

113. **M. grandiflora** L.—This species is indigenous to Florida. According to Delpino (op. cit., pp. 233–5), the white odorous protogynous flowers are visited and pollinated by beetles (Cetoniae). During the first stage of anthesis, these insects find under the three inner petals, which arch over the carpels, a warm nectar-containing shelter, that they only leave when the petals are shed at the time of dehiscence of the anthers. Dusted with pollen they then betake themselves to another flower in the first stage, the mature stigmas of which they necessarily pollinate. Self-pollination is prevented by the pronounced protogyny.

VISITORS.—Cetonia aurata *L.*, and Oxythyrea funesta *Poda* (= C. stictica *L.*).

IV. ORDER *ANONACEAE* JUSS.

28. Asimina Adans.

114. **A. triloba** Dunal.—Delpino states (op. cit., p. 231) that the stamens project in the centre of the pendulous protogynous flower as a hemispherical mass, from the middle of which a few styles with their stigmas project. In the first (female) stage of anthesis the three inner petals lie so close to the stamens that insect visitors (flies) cannot suck the nectar secreted at the bases of the former without touching the already mature stigmas. In the second (male) stage the stigmas have dried up and the inner petals have raised themselves, so that the anthers—now covered with pollen—are touched by insects on their way to the nectar. Cross-pollination of the younger flowers is therefore effected by transference from the older ones.

VISITORS.—Delpino observed the following seven Muscidae, which were determined by Rondani.—

1. Calliphora erythrocephala *Mg.*; 2. Lucilia sericata *Mg.*; 3. Cyrtoneura pascuorum *Mg.*; 4. C. stabulans *Fall.*; 5. C. assimilis *Fall.*; 6. Homalomyia prostrata *Rossi*; 7. Megaglossa umbrarum *Mg.*

V. ORDER *BERBERIDEAE* VENT.

29. Berberis L.

Homogamous flowers with half-concealed nectar, arranged in dense racemes, so that in spite of the relative smallness of the individual blossoms, they are very conspicuous in the aggregate. The inner sides of both sepals and petals are yellow in colour. Nectar is secreted by two fleshy swellings on the inner side of each petal near its base, and owing to the concave shape of the corolla these are tolerably well concealed. Many species possess sensitive stamens, which suddenly move towards the pistil when they are touched at the base of their inner surface.

115. B. vulgaris L. (Sprengel, 'Entd. Geh.,' pp. 203–6; Herm. Müller, 'Fertilisation,' pp. 90–3, 'Weit. Beob.,' I, p. 323, 'Alpenblumen,' p. 142; Kirchner, 'Flora v. Stuttgart,' p. 255; Knuth, 'Grundriss d. Blütenbiol.,' 'Bloemenbiol. Bijdragen.')—Sprengel, who first described the structure of the flowers, believed them to be self-pollinated:—'When a stamen that has been touched by an insect applies itself to the pistil, it presses the inner side of its apex—which is covered with pollen—

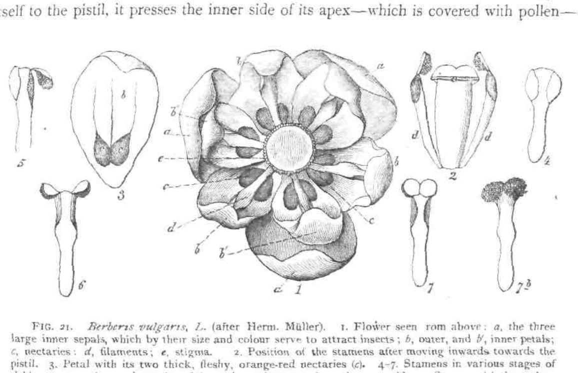

FIG. 21. *Berberis vulgaris*, *L.* (after Herm. Müller). 1. Flower seen rom above: *a*, the three large inner sepals, which by their size and colour serve to attract insects; *b*, outer, and *b'*, inner petals; *c*, nectaries: *d*, filaments; *e*, stigma. 2. Position of the stamens after moving inwards towards the pistil. 3. Petal with its two thick, fleshy, orange-red nectaries (*c*). 4–7. Stamens in various stages of dehiscence, erection, and rotation of the anther-valves, seen from the outer side. 4. Stamen with the anther-lobes still closed. 5. The outer wall of the right anther-lobe has become free below, so as to form a valve, of which the free end is beginning to turn upwards with the pollen attached to it. 6. Both valves have nearly completed their upward movement. 7. Both valves have turned in such a way that the pollen-masses are directed towards the middle of the flower. 7 *b*. Inner side of a stamen in this stage.

closely to the stigma, and this being moist, a part of the pollen must adhere to it. The stigma is thus gradually pollinated all round, and the ovary is fertilized.'

Hermann Müller proved this view to be erroneous, and explained the flower mechanism as an adaptation to cross-pollination.

The flowers are either horizontal or hang obliquely downwards (not vertically downwards as described and figured by Sprengel). They are, therefore—as Hermann Müller emphasizes—not fully sheltered by their position from the entry of rain, though a tolerable amount of protection is afforded by the three inner concave

sepals, which are curved inwards at the tip rather more sharply, and by the six similarly shaped petals, which completely enclose the stamens so long as they are not disturbed, and cover the anthers with their ends.

The nectaries are in the form of two thick orange-coloured bodies on the base of each petal, placed so close together as to touch each other. The stamens—before they have been stimulated—lie so near the nectaries that the nectar collects in the angle between the filaments and the carpels. The adhesive margin of the disk on the top of the pistil functions—as Sprengel recognized—as a stigma. It matures simultaneously with the stamens.

When an insect in quest of nectar comes into contact with the broad sensitive bases of the filaments, these suddenly move inwards towards the pistil, so that the head or proboscis of the insect comes between the dehisced anthers and the stigmatic margin, which is at the same level. As a rule the insect then leaves the flower, and goes to another one, effecting cross-pollination in the latter if it touches the stigma with that side of its body which is dusted with pollen. Should insect-visits fail self-pollination automatically takes place when the flowers fade, for then the anthers themselves come into contact with the stigma. Self-pollination, however, does not always seem to be effective, for many flowers fail to set fruits.

According to Pfeffer, the movement of the stamens is caused by the flow of water to the stimulated part. Chauveaud ('Mécanisme des mouvements provoqués de Berberis,' C.-R. Acad. sci., Paris, cxix, 1894, pp. 103–5) describes a special tissue concerned in the movement, and consisting of elongated narrow cells almost fused together, with small intercellular spaces, especially at their ends. The transverse walls of these cells are thin, their longitudinal ones, on the contrary, are thick with numerous scattered pits. These last render possible both a very rapid interchange between the cells, and also a quick bending of this elastic tissue. It is covered by thin-walled cells, the contents of which constitute the active irritable element. When in the resting condition, the protoplasm of each cell of the motile tissue forms a thick band applied to the posterior cell-wall. On stimulation, this suddenly becomes lax, spreads out, curves like a bow, and while its edges pull upon the transverse walls its convex central part presses against the outer wall, which becomes more strongly arched. Hence the cell becomes shorter and thicker. This change in the motile tissue causes the filaments to bend inwards.

VISITORS.—In accordance with the position of the nectar, these are mostly insects with a medium or short proboscis. They all suck nectar, only a few bees also collecting pollen. H. Müller (H. M.) and myself (Kn.) have observed the following.—

A. Coleoptera. (*a*) *Coccinellidae*: Coccinella conglobata *L.* (= C. quattuorpunctata *L.*), skg. (H. M.); 2. C. septempunctata *L.*, freq., skg. (Kn.); 3. C. variabilis *Hbst.*, nect-lkg. (H. M.). (*b*) *Dermestidae*: 4. Attagenus pellio *L.*, skg. (H. M.). **B. Diptera.** (*a*) *Muscidae*: 5. Musca corvina *F.*, skg. (H.M.); 6. Musca domestica *L.*, skg. (H. M., Kn.); 7. Onesia cognata *Mg.*, ditto (H. M.); 8. O. floralis R.-D., ditto (H. M.); 9. O. sepulcralis *Mg.*, ditto (H. M.). (*b*) *Syrphidae*: 10. Ascia podagrica *F.*, freq., skg. (H. M.); 11. Eristalis arbustorum *L.*, skg. (H. M., Kn.); 12. E. nemorum *L.*, ditto (H. M.); 13. E. pertinax *Scop.*, ditto (Kn.); 14. E. tenax

L., ditto (H.M., Kn.); 15. Helophilus floreus *L.*, ditto (H.M.); 16. H. pendulus *L.*, ditto (H. M., Kn.); 17. Rhingia rostrata *L.*, ditto (H. M., Kn.); 18. Syrphus balteatus *Deg.*, ditto (Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 19. Andrena albicans *Müll.* ♀, ditto (H. M., Kn.); 20. A. fulva *Schr.* ♀, tolerably freq., skg. and po-cltg. (H. M.); 21. A. fulvicrus *K.* ♀, in large numbers, skg. (H. M.); 22. A. helvola *L.* ♂, skg. (H. M.); 23. K. praecox *Scop.* ♀, ditto (H. M.); 24. A. trimmerana *K.* ♀, ditto (H. M.); 25. Apis mellifica *L.* ☿, freq., skg. (H. M., Kn.); 26. Bombus pratorum *L.* ♀, skg. (H. M.); 27. B. terrester *L.* ☿, ditto, freq. (H. M., Kn.); 28. Halictus rubicundus *Chr.* ♀, skg. (H. M.). (*b*) *Formicidae*: 29. Lasius niger *L.* ☿, nect-lkg. (H. M.). (*c*) *Vespidae*: 30. Vespa holsatica *F.* ☿ skg. (H. M.); 31. V. rufa *L.* ☿, ditto (H. M.).

Hermann Müller also observed—in the Alps—14 flies, 3 beetles, and 9 Lepidoptera. In the Tyrol, von Dalla Torre noticed the bees Andrena trimmerana *K.* ♀, and A. atriceps *K.* ♂; to which Kohl adds—for the same region—the ruby-wasp Ellampus aeneus *F.* and the true wasp Leionotus nigripes *Pz.*, while Schletterer records Andrena tibialis *K.*, and A. trimmerana *K.* Schiner—in Austria—observed the hover-fly Criorhina berberina *F.*

Ricca ('Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.') observed humble-bees and wasps; H. de Vries (Ned. Kruidk. Arch., Nijmegen, see note, p. 23, 1887) records Apis mellifica *L.* ☿, as a very common visitor in the Netherlands.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 7) were observed—2 humble-bees, one of the short-tongued Apidae, and 2 hover-flies.

116. **B. aquifolium** Pursh (=Mahonia aquifolium *Nutt.*).—This is an ornamental shrub indigenous to North America. Its flowers agree in structure with those of the last species.

Visitors.—I have observed Syrphids (Eristalis tenax *L.*, Syrphus ribesii *L.*, Rhingia rostrata *L.*), the honey-bee, Andrena albicans *Müll.* ♀, and 2 humble-bees (Bombus terrester *L.* ♀, and B. lapidarius *L.* ♀); also a few Muscids. All skg. Schletterer noted at Pola 2 of the Apidae (1. Bombus terrester *L.*, 'from Christmas-time till the end of January'; and 2. Xylocopa violacea *L.*).

30. Epimedium L.

Protogynous flowers with concealed nectar. The blood-red petals serve to attract insects. The cup-shaped nectaries—which make up a corona—are yellow, and possess a short protuberance secreting nectar.

117. **E. alpinum** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 234; Loew, 'Blütenbiol. Floristik,' p. 182; Knuth, 'Bloemenbiol. Bijdragen.')—The anthers dehisce by valves, which come together above the already mature stigma, though they cannot pollinate it, as the flowers are pendulous in this stage. The blossoms become erect later on, and pollen can now fall on the stigma. Automatic self-pollination is ensured by elongation of the pistil till it comes into contact with the anthers.

According to Warnstorf, the pollen is yellow, ellipsoidal, covered with delicate papillae, and on the average 43 μ long, and 31 μ broad.

Visitors.—On May 2, 1896, I had the opportunity of watching the honey-bee visiting and pollinating this interesting flower in the Botanic Garden of the Kiel

Ober-Realschule. It went in a methodical way all round the flower and sucked the nectaries in succession. On alighting it touched the stigma—which projected to a distance of 1 mm.—and dusted it with pollen brought from another flower. While the bee was sucking nectar a fresh supply of pollen adhered to its ventral surface.

118. **E. pinnatum** Fisch. (Loew, 'Blütenbiol. Beiträge,' I, p. 5.)—This species—indigenous to Persia and the Caucasus—is protogynous in the Berlin Botanic Garden. It agrees in structure—though not in size and colour—with E. alpinum.

VISITORS.—Loew observed Osmia rufa, *L.*, skg.

119. **E. macranthum** Lindl.—According to Loew's investigations ('Blütenbiol. Beiträge,' I, p. 6) in the Berlin Botanic Garden, this flower has long thin spurs, which conceal the nectar in such a way that bees with a long proboscis are the most likely pollinators.

120. **E. violaceum** Morr. et Decne.—This is similar in structure to the last species, with which it is perhaps identical (Loew, 'Blütenbiol. Beiträge,' I, p. 6).

121. **E. rubrum** Morr. (Loew, 'Blütenbiol. Beiträge,' I, p. 6.)—Like the two preceding species this is indigenous to Japan. Its flowers have a relatively thick spur, and like those of the other species are protogynous.

VISITORS.—Loew observed Bombus agrorum, *F.* ♀, skg., in the Berlin Botanic Garden.

31. Podophyllum L.

Pollen flowers devoid of nectar and nectar-guides.

122. **P. Emodi** Wall. (Loew, 'Blütenbiol. Beiträge,' I, p. 8.)—This Himalayan species is probably pollinated by visitors which settle on the stigma, and then pass on to the stamens in order to collect pollen. Cross-pollination must result from a visit to a second flower. As the stigma projects above the anthers, automatic self-pollination is excluded.

123. **P. peltatum** L. (Loew, 'Blütenbiol. Beiträge,' I, p. 9.)—The number of floral members of this North American species frequently varies. The stamens project even in the bud.

32. Achlys DC.

124. **A. triphylla** DC.—According to Calloni (Arch. Sci. Phys., Genève, xviii, 1886), this plant possesses three kinds of flowers in every inflorescence: the lower are barren, the middle are in part fertile, the upper ones are all fertile.

33. Akebia Decne.

125. **A. quinata** Des.—According to Francke ('Einige Beitr. z. Kennt. d. Bestäubungseinricht. d. Pfl.,' Inaug.-Diss., Freiburg i. Br., Halle, 1883), cross-pollination is effected either by the wind or by insects. The female flowers are developed long before the male ones.

VI. ORDER *NYMPHAEACEAE* DC.

LITERATURE.—Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 20–1; Caspary, in Engler and Prantl., 'D. nat. Pflanzen-Fam.,' III, 2, pp. 1–10, Leipzig, 1888.

The large floating flowers are protected from creeping animals by their aquatic habitat, and are only accessible to flying insects. The inner side of the sepals is coloured like the petals, so that both whorls are conspicuous. A more or less distinct odour of honey also serves as a further attraction to insects.

34. Nymphaea L.

Homogamous or slightly protogynous pollen flowers with an odour of honey. The stigma secretes a moisture which is, perhaps, licked by insects: according to Jordan, however, there are flat nectaries in front of the stamens, in which case the flowers should be placed in class **EC** or **C.** The white inner surface of the sepals, and of the numerous petals—which gradually pass into the stamens—makes the flower conspicuous.

126. N. alba L. (Delpino, 'Alc. appunti d. geog. bot.,' Boll. Soc. geogr. ital., Roma, v, 1869; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 21, 148, 'Weit. Beob.,' p. 231; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 218; Schulz, 'Beiträge,' II, p. 9; Watson, Justs bot. Jahresber., Leipzig, xii (1884), 1886, p. 682; Caspary, op. cit.)—The faintly odorous, large, white flowers, which open in the morning and close towards evening, are homogamous according to my observations. Kerner states that the stigmatic papillae are mature at the beginning of anthesis, remaining receptive for several days. The anthers begin to dehisce when the flower opens, or a day—rarely a few days—later. The filaments bend into the form of a sickle, so as to bring the anthers above the stigmas, which spread out into a plate-like surface, so that self-pollination must result from falling of the pollen. Insect visitors may effect either cross- or self-pollination, but they are few in number. The flowers are usually 10 cm. or even more in diameter. In dried-up marshes, however, on the Island of Föhr, I found flowers of only 5 cm. diameter, and these I have described ('Flora d. nordfr. Ins.,' p. 32) as the variety *terrestris*.

VISITORS.—On the Island of Föhr I observed a diminutive fly (Notiphila cinerea *Fall.*), freq. Heinsius—in Holland—noted a species of the same genus (Notiphila nigricornis *Stenh.*). Schulz—for central Germany—has recorded various flies and beetles. MacLeod—in Flanders—observed a beetle (Domicia) (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 183).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 7), Apis, a humble-bee, and Muscids have been observed.

35. Victoria Lindl.

127. Victoria Regia Lindl.—The flowers, which may be as large as dinner-plates, are first white, and then rose-coloured.

• VISITORS.—Delpino believes that the flowers are pollinated by Cetoniae and Glaphyridae.

36. Nuphar Sm.

Flowers homogamous, or slightly protogynous, with nectar partly or completely concealed, secreted by the backs of the petals, and collected in the angle between sepals and petals. The sepals, which are yellow on their inner surfaces, and the other floral whorls, which are of the same colour, serve to attract insects.

128. **N. luteum** Sm. (Sprengel, 'Entd. Geh.,' p. 273; Herm. Müller, 'Fertilisation,' p. 93; Caspary, op. cit.; Schulz, 'Beiträge,' II, pp. 10–11; Kirchner, 'Flora v. Stuttgart,' p. 276; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 183–4; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 21, 'Weit. Beob.,' p. 226, note 1; Axell, 'Om anord. för fanerog. växt. befrukt.,' p. 104; Warnstorf, Verh. bot. Ver., *Berlin*, *xxxvii*, *1895*.)—The egg-yolk yellow flowers are strongly odorous. They are either homogamous or—according to Caspary and Schulz—protogynous, the stigmas being fully mature at the commencement of anthesis, while the anthers dehisce somewhat later in centripetal order. The stamens move towards the petals as they ripen, so that automatic self-pollination is excluded.

Warnstorf also describes the flowers as protogynous, and states that when the sepals are closed the stamens are pressed together round the ovary beneath the stigma, but later on, when the anthers dehisce, they bend back, so that the pollen on their inner surfaces is encountered by small insect visitors. The spinose pollen-grains are large, yellow, and ellipsoidal, with an average length of 63 μ, and an average breadth of 37·5 μ. The spines may be as much as 8·75 μ long. Insects creeping about on the flowers effect either cross- or self-pollination.

Visitors.—Hermann Müller (H. M.) and myself (Kn.) have observed the following.—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Donacia dentata *Hoppe* (H. M.); 2. D. sparganii *Ahr.* (Kn.); (*b*) *Nitidulidae*: 3. Meligethes (Kn.). **B. Diptera.** *Muscidae*: 4. Calliphora vomitoria *L.* (Kn.); 5. Scatophaga sp. (Kn.); 6. Onesia floralis *R.-D.* (H. M.). **C. Neuroptera.** 7. Phryganidae (Kn.). Flies and beetles have also been recorded by Schulz.

Heinsius observed in Holland numerous flies (Notiphila nigricornis *Stenh.*, and Cleigastra sp.) (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, pp. 61–3).

37. Euryale Salisb.

129. ***E. ferox*** Salisb.—Goebel ('*Pflanzenbiol. Schilder.*,' *II*, *2*, p. 363) observed only submerged cleistogamous flowers on cultivated plants in the Marburg Botanic Garden, while in the Munich Garden the flowers rose above the surface and unfolded their bluish-violet petals.

VII. ORDER *SARRACENIACEAE* ENDL.

38. Sarracenia L.

130. **Sarracenia purpurea** L.—Hildebrand states (Ber. D. bot. Ges., Berlin, i, 1883) that this species is homogamous, though cross-pollination is promoted, for there are recurved hooks on the stigma, which compel insect visitors to make their exit to one side of the stigmatic surface.

VIII. ORDER *PAPAVERACEAE* DC.

1. Sub-order Papavereae.

Homogamous, slightly protogynous, rarely protandrous pollen flowers. In the bud the inner floral whorls are protected by the strong calyx, composed of two or three sepals, or cap-shaped. After discharging this function the calyx falls off when the petals unfold. The large, usually vividly-coloured, petals make the flowers conspicuous from a distance. Sometimes this is enhanced by the colour of the stamens.

39. **Papaver** Tourn.

Pollen flowers with large brilliantly coloured petals.

131. P. alpinum L. (Herm. Müller, 'Alpenblumen,' pp. 142–3; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 120; Hoffmann, referred to in Darwin, 'Cross- and Self-Fertilisation,' p. 331.)—The flowers sometimes smell of hawthorn, sometimes of musk. In the Alps the petals are citron-yellow, with a paler sulphur-yellow or greenish base; in Carniola they are dark yellow; in Lower Austria and Steiermark they are white, usually with a yellow base.

The flowers are homogamous. The pistil is situated in the middle of the deeply concave corolla, which is 30 to 35 mm. wide. The 5–8 radiate stigmas are mature when the flowers open, and at the same time the anthers of some of the outermost of the numerous stamens dehisce. Insects visiting the flowers for the sake of the very abundant pollen may therefore effect either cross- or self-pollination.

The flowers remain half-closed in dull weather, and Kerner states that they are open only in the forenoon. The inner stamens converge together above the stigmas, and dust them with pollen. This automatic self-pollination has, however, very little result, for—according to H. Hoffmann—garden plants invariably proved self-sterile (Darwin, 'Cross- and Self-Fertilisation,' p. 331).

Visitors.—Hermann Müller observed several flies in the Alps.

132. P. nudicaule L. (=P. radicatum *Rottb.*).—Warming states that self-pollination is almost inevitable in the sulphur-yellow or white pollen flowers of this Arctic species, and it must be effective, for ripe fruits have frequently been observed, though owing to the dearth of insects in the Northern region, cross-pollination hardly ever occurs. Focke states, however, that cultivated plants are self-sterile. According to Ekstam, the diameter of the faintly odorous flower is 20–40 mm. in Nova Zemlia. Self-pollination is possible here even in the bud.

This species flowers in Spitzbergen, according to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 41–2), from the end of June to the end of August, regularly setting fruits. The corolla is 25–52 mm.—on an average 58 mm.—in diameter. Its colour is greenish-yellow, often shading into white at the bases of the petals; but frequently it may be pure sulphur-yellow, or sometimes perfectly white. The peduncle becomes curved during rain, so that the opening of the flower faces downwards, and wet is kept out. The pollen-grains are not injured by moisture, and germinate in distilled water after three or four hours. Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 21) found the flowers to be homogamous or feebly protogynous-homogamous in Spitzbergen,

with a strong tendency to autogamy, for both kinds of sexual organ mature in the bud, and the stamens bend toward the stigmas when the flower opens. The latter are 4–7 in number in Greenland (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlands exped.,' p. 29).

VISITORS.—In Nova Zemlia flies were observed by Ekstam, who also noticed a small po-dvg. fly on the flowers in Spitzbergen, at a height of 1000′ above the sea-level.

Alfken saw at Bremen the following pollen-collecting Apidae on garden plants.—

1. Andrena albicans *Müll.* ♀; 2. A. nigro-aenea *K.* ♀; 3. A. nitida *Fourcr.* ♀; 4. A. parvula *K.* ♀; 5. Osmia rufa *L.* ♀. All po-cltg.

133. **P. Rhoeas** L. (Herm. Müller, 'Fertilisation,' 93–4, 'Weit. Beob.,' I, 323; Hoffmann, 'Bot. Ztg.,' Leipzig, xxxvi, 1878, p. 290; Beyer, 'D. spont. Bewegungen d. Staubgefässe u. Stempel'; Kirchner, 'Flora v. Stuttgart,' p. 277; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 22, 148.)—The petals are scarlet, with a black patch at the base. Even in the bud the numerous stamens are mature, so that the pollen-covered anthers come into contact with the lower parts of the flattened but already mature stigmas, and dust them with pollen. Hoffmann states, however, that this inevitable automatic self-pollination is ineffective. After the flowers have opened either cross- or self-pollination may be brought about by insect-visits. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) describes the pollen-grains as grey-green, and spherical or almost spherical when examined in water, very finely granular, with an average of 37·5 μ.

VISITORS. — Hermann Müller (H. H.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes, very freq., po-dvg. (H. M.); (*b*) *Oedemeridae*: 2. Oedemera virescens *L.*, po-dvg. (H. M., Thuringia). (*c*) *Scarabaeidae*: 3. Oxythyrea funesta *Poda*, very freq., dvg. the flowers (H. M.). **B. Diptera.** (*a*) *Empidae*: 4. Empis livida *L.* (H. M.). (*b*) *Muscidae*: 5. Ulidia erypthrophthalma *Mg.* (H. M., Thuringia). (*c*) *Syrphidae*: 6. Cheilosia, po-dvg. (H. M.); 7. Syrphus ribesii *L.*, po-dvg. (Kn.); 8. S. umbellatarum *F.*, po-dvg. (Kn.). **C. Hymenoptera.** *Apidae*: 9. Andrena dorsata *K.* ♀, freq., po-cltg. (H. M.); 10. A. fulvicrus *K.* ♀, freq., po-cltg. (H. M.); 11. Apis mellifica *L.* ☿ (Kn.); 12. Bombus terrester *L.* (Kn.); 13. B. lapidarius *L.* ♀, and 14. Halictus cylindricus *K.* ♀; all po-cltg. (H. M.); 15. H. flavipes *F.* ♀, freq., po-cltg. (H. M.); 16. H. leucopus *K.* ♀, po-cltg. (H. M., Thuringia); 17. H. longulus *Sm.* ♀, po-cltg. (H. M.); 18. H. maculatus *Sm.* ♀ (H. M.); 19. H. sexnotatus *K.* ♀, very freq., po-cltg. (H. M.); 20. H. smeathmanellus *K.* ♀, po-cltg. (H. M., Thuringia). **D. Orthoptera.** 21. Forficula auricularia *L.* (H. M.). Friese noted—in Mecklenburg—Osmia papaveris *Ltr.*, occasional; Schletterer—at Pola—Eucera longicornis, *L.*; MacLeod—in the Pyrenees—Bombus terrester, *L.* ☿, po-cltg., also — in Flanders — 3 hover-flies (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 184–5).

134. **P. Argemone** L. (Herm. Müller, 'Fertilisation,' p. 94; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 185–6; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 22, 148; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The red petals are blotched with black at their bases. The flowers agree in structure with those of the last species, except that the anthers come into contact with a smaller part of the stigmas. Warnstorf describes them as pseudo-cleistogamous, because the

sky-blue anthers dehisce before they open, and pollinate the already mature stigmas. The bluish, spherical pollen-grains are opaque owing to the presence of minute wart-like projections. Their average diameter is 50 μ.

VISITORS.—I observed—at Kiel—a hover-fly, Platycheirus podagratus *Lett.*, po-dvg.

135. **P. somniferum** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 190; Kirchner, 'Flora v. Stuttgart,' p. 278; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 22, 148.)—The petals are either carmine to violet in colour, often blackish at the base, or else white with a lilac base. The flowers agree in structure with those of P. Argemone and P. Rhoeas, but in the bud the anthers project over the stigma-lobes—which are still folded down—so that before anthesis not only the lower but all the stigmatic papillae are thickly covered with pollen. This automatic self-pollination is partly effective. Owing to the size of the flower, however, insect-visits are very numerous, so that in favourable weather cross-pollination is assured. The Diptera (Syrphidae) which I observed visiting the flower almost always alighted upon the large upper-surface of the pistil with its radiating stigmas—from which the stamens move away when the flower opens—and then go to the anthers, so that cross-pollination must be effected by a second visit. The humble-bees observed by me as visitors only now and then touched the stigmas, for they almost always alighted upon the crowded stamens, and then wandered about among these collecting pollen. Warnstorf (Ver. bot. Ver., Berlin, xxxviii, 1896) describes the whitish pollen-grains as ellipsoidal, with a length of about 44 μ, and a breadth of 28 μ.

VISITORS.—The following insects have been observed by Buddeberg (Budd.) in Nassau, and by myself (Kn.) in Schleswig-Holstein.—

A. Coleoptera. (*a*) *Scarabaeidae*: 1. Cetonia stictica *L.*, devg. the flowers (H. M.). (*b*) *Nitidulidae*: 2. Meligethes sp. (Kn.). **B. Diptera.** *Syrphidae*: 3. Eristalis aeneus *Scop.* (H. M.); 4. E. arbustorum *L.* (H. M., Kn.); 5. E. tenax *L.* (Kn.); 6. Platycheirus peltatus *Mg.* (Kn.); and 7. Syrphus sp. (Kn.), all po-dvg. **C. Hymenoptera.** *Apidae*: 8. Apis mellifica *L.* ☿, freq. (Kn.); 9. Bombus terrester *L.*, freq. (Kn.); 10. Eriades campanularum *K.* ♀ (H. M.); 11. E. truncorum *L.* ♀ (H. M.); 12. Halictus cylindricus *F.* ♀ (H. M.); 13. H. leucopus *K.* ♀ (H. M.); all po-cltg.

136. **P. dubium** L. (Herm. Müller, 'Fertilisation,' p. 94.)—Automatic self-pollination is rendered difficult in this species because the anthers stand a few millimetres below the stigma; it can therefore only take place in flowers which are bent downwards. Hermann Müller is of opinion that the very great rarity of this plant in some districts is perhaps due to the impossibility of autogamy. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) describes the pollen as yellow, spherical to ellipsoidal when examined in water, marked with several longitudinal furrows, and 31–37 μ in diameter.

VISITORS.—MacLeod—in Flanders—observed small flies (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 186).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 8) there have been noted 3 Muscidae, a hover-fly, and Meligethes.

137. **P. argemonoides** L.—Hildebrand states that this species is fertile when self-pollinated.

138. **P. hybridum** L.—According to Hoffmann, this species—at least in gardens—possesses cleistogamous flowers.

VISITORS.—Schletterer—at Pola—observed the bee Halictus calceatus *Scop.*

139. **P. bracteatum** Lindl.—

VISITORS.—Loew noticed Apis mellifica *L.* ☿ in the Berlin Botanic Garden, po-cltg., and creeping over the stigma.

140. **P. burseri** Crantz.—

VISITORS.—In the Berlin Botanic Garden, Loew noticed a long-tongued bee (Osmia rufa *L.* ♀, po-cltg.).

40. Glaucium Tourn.

Homogamous or slightly protogynous pollen flowers, devoid of odour, and red or yellow in colour.

141. **G. flavum** Crantz (=G. luteum *Sm.*). (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 310; Kirchner, 'Beiträge,' p. 19; Knuth, 'Blütenbiol. Herbstbeob.')—The large citron-yellow petals fall off on the second day of flowering. The stigma—which Kerner says develops somewhat earlier than the anthers—projects a little beyond the stamens, so that automatic self-pollination is prevented.

VISITORS.—On cultivated plants at Kiel I observed as pollinating agents numerous individuals of a hover-fly species (Syrphus ribesii *L.*), po-dvg., and also several butterflies (Vanessa Io *L.*, and Rhodocera rhamni *L.*), vainly searching for nectar. Kirchner—at Hohenheim—noticed the honey-bee and Thrips; while Loew—at Bellagio—saw Xylocopa violacea *L.* ♀, po-cltg. In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 9) there have been recorded 2 Muscidae, a hover-fly, and Meligethes.

142. **G. corniculatum** Curt. (= G. phoeniceum Crantz). (Kerner, op. cit., p. 213; Knuth, op. cit.)—The flower is bright red, with a black patch on the base of each petal. Its structure is the same as in the last species.

VISITORS.—In the case of cultivated plants growing beside those of the last species, the visitors to the two were identical.

41. Chelidonium L.

Homogamous pollen flowers with yellow petals.

143. **C. majus** L. (Sprengel, 'Entd. Geh.,' p. 271; Herm. Müller, 'Fertilisation,' p. 94, 'Weit. Beob.,' I, p. 323; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.,' p. 60; Kirchner, 'Flora v. Stuttgart,' p. 279; Knuth, 'Blütenbiol. Herbstbeob.,' 'Bloemenbiol. Bijdragen'; Warnstorf, Verh. bot. Ver., Berlin, xxxvii, 1896.)—The flowers open in sunny weather. The anthers dehisce laterally, and the stigma matures simultaneously. As the latter projects somewhat beyond the stamens, cross-pollination is effected by insects coming from other flowers of the same species, and alighting in the centre of the flower, while insects settling on the edge of the blossom may

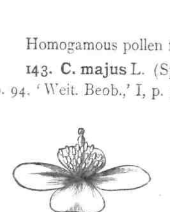

FIG. 22. *Chelidonium majus, L.* (after Hildebrand). The stigma projects beyond the anthers.

effect either kind of pollination. During dull weather the flowers remain closed for a long time, in which case the anthers dehisce in the bud and effect self-pollination. Warnstorf describes these flowers as varying from slightly protogynous to homogamous, and from this to protandrous. The pollen-grains are of a beautiful yellow colour, rounded, finely tuberculated, and measuring up to 37 μ in diameter.

VISITORS.—These are chiefly insects vainly seeking for nectar, and next to them come pollen-collecting bees and pollen-devouring flies. The larger bees (humble-bees and the honey-bee) alight as a rule on the middle of the flower, thus effecting cross-pollination, while smaller forms (species of Halictus) usually settle on the edges of the blossoms, and only occasionally touch the stigma, in which case either kind of pollination is equally probable. Hover-flies behave in the same way.

The following visitors have been determined by Hermann Müller (H. M.) in Westphalia, and by myself (Kn.) in Schleswig-Holstein.—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, po-dvg. (Kn.). (*b*) *Nitidulidae*: 2. Meligethes, po-dvg. (H. M.). **B. Diptera.** (*a*) *Empidae*: 3. Empis livida *L.*, vainly searching for nectar, or perhaps boring (H. M.). (*b*) *Syrphidae*: 4. Ascia podagrica *F.*, po-dvg. (H. M.); 5. Eristalis arbustorum *L.*, po-dvg. (H. M.); 6. E. nemorum *L.*, po-dvg. (Kn.); 7. E. pertinax *Scop.*, po-dvg. (Kn.); 8. Helophilus pendulus *L.*, po-dvg. (Kn.); 9. Melanostoma mellina *L.*, po-dvg. (Kn.); 10. Melithreptus taeniatus *Mg.*, po-dvg. (Kn.); 11. Rhingia rostrata *L.*, first vainly searching for nectar, then po-dvg. (H. M.); 12. Syritta pipiens *L.*, po-dvg. (H. M.); 13. Syrphus balteatus *Deg.*, po-dvg. (H. M., Kn.); 14. S. ribesii *L.*, po-dvg. (H. M., Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 15. Anthophora pilipes *F.* ♀, po-cltg. (Kn.); 16. Apis mellifica *L.* ☿, po-cltg. (H. M., Kn.); 17. Bombus agrorum *F.* ☿, po-cltg. (H. M., Kn.); 18. B. hortorum *L.* ☿, po-cltg. (Kn.); 19. B. lapidarius *L.* ☿, po-cltg. (Kn.); 20. B. pratorum *L.* ☿, po-cltg. (H. M.); 21. B. rajellus *K.* ☿, po-cltg. (H. M.); 22. B. terrester *L.*, po-cltg. (Kn.). Herm. Müller noticed that humble-bees settle on the middle of the flower, sweep pollen very rapidly from the anthers with the tarsal-brushes of the first two pairs of legs, and immediately transfer it to the 'baskets' of the hind-legs, completing the operation in from two to three seconds, and then at once flying away to another flower to treat it in the same fashion, thus effecting cross-pollination. 23. Halictus cylindricus *F.* ♀ (H. M.); 24. H. sexnotatus *K.* ♀ (H. M.); 25. H. sexstrigatus *Schenck* ♀ (H. M.); 26. H. zonulus *Sm.* ♀ (H. M.); these four species of Halictus fly to the anthers to collect pollen, occasionally touching the stigma.

Loew observed—in the Berlin Botanic Garden—a hover-fly, Syrphus balteatus *Deg.*, po-dvg.; Alfken — at Bremen — 3 po-cltg. Apidae, Bombus lucorum *L.* ☿, Andrena nitida *Fourc.* ♀, and A. nigro-aenea *K.* ♀, the last two flying laboriously with disarranged wings, and carrying very heavy loads of pollen, destined to store cells in the case of the last-named species; Hoffer records from Steiermark, Bombus agrorum *F.* ☿, carrying huge loads of pollen, and Bombus terrester *L.* ☿ freq.; MacLeod noted in Flanders, Apis, 3 humble-bees, 2 species of Halictus, 5 hover-flies, and a Muscid (B. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 186–7).

42. Eschscholtzia Cham.

Homogamous pollen flowers, usually yellow in colour.

144. **E. californica** Cham. (F. Müller, Bot. Ztg., Leipzig, xxvi, 1868; Darwin, op. cit., xxvii, 1869; Hildebrand, Jahrb. wiss. Bot., Leipzig, vii, 1869–70; Herm. Müller, 'Fertilisation,' pp. 94–5, 'Weit. Beob.,' I, p. 323; Knuth, 'Blütenbiol. Herbstbeob.')—The filiform stigmas are at first closely surrounded by the crowded stamens, but

in a later stage of anthesis, the latter bend out towards the somewhat remote petals, after which the outer set of anthers dehisce, while those of the inner stamens are still unopened. The centrally placed stigma—which is now mature—cannot therefore receive pollen from the same flower, but may be cross-pollinated if insects that have visited other blossoms alight upon it. At a still later stage the anthers of the inner stamens dehisce so that self-pollination may take place if insect-visits have failed. Fritz Müller states, however, that this is ineffective in South Brazil, though in England—according to Darwin—the contrary is true. It is remarkable that Brazilian plants sent by Fritz Müller to Charles Darwin were to some extent self-fertile. Hildebrand found the plant to be almost self-sterile in Germany.

VISITORS.—In sunny weather I observed the bright yellow flowers to be visited by numerous individuals of a species of hover-fly (Syrphus ribesii *L.*), which alighted in an erratic fashion sometimes upon the stigma, sometimes upon the stamens or petals, so that at times they effected cross-pollination, at other times self-pollination. I frequently saw five or six of these flies in a single flower, and they remained there so persistently that I could pluck the flower and examine it with a lens, while the visitors remained undisturbed and continued to devour pollen. They were thickly covered with this on the head, and especially on the upper- and under-surfaces of the thorax. Herm. Müller observed another hover-fly (Helophilus floreus *L.*) visiting the flowers.

43. **Sanguinaria** L.

Pollen flowers devoid of nectar and nectar-guides.

145. **S. canadensis** L. (Loew, 'Blütenbiol. Beiträge,' I, pp. 9, 10.)—In this North American plant the inner stamens project a little beyond the stigma, while the outer ones are somewhat shorter.

VISITORS.—Loew observed in the Berlin Botanic Garden, Apis and Bombus terrester *L.* ♀, both po-cltg.

2. SUBORDER FUMARIEAE DC.

LITERATURE.—Hildebrand, Jahrb. wiss. Bot., Leipzig, 1869; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 23.—The flower mechanism of the species of this family has been thoroughly and carefully investigated by Hildebrand, and Hermann Müller has determined the visitors. The following remarks are chiefly based upon the researches of these two investigators.

The Fumarieae bear homogamous bee flowers of peculiar structure. Being as a rule large and brightly coloured, often aggregated into racemes, and not infrequently exhaling a more or less strong odour of honey, these naturally attract insects. The nectar is secreted and concealed in spurs or pouches of the petals, and there are either two such nectaries (Diclytra and Adlumia), or only one (Corydalis, Fumaria). The two inner petals are fused at the tip, and so form a hood-like sheath, which encloses anthers and stigmas. This hood is pressed downwards or to the side by nectar-seeking bees, but when the pressure is removed it usually springs back by elasticity to its original position. Bees dust themselves with pollen in the younger flowers, and transfer some of it to the stigmas of older flowers that

have already been robbed of their pollen. As they visit the flowers of an inflorescence in a systematic manner, working from below upwards, they regularly effect cross-pollination, either geitonogamy or—when passing from one plant to another—xenogamy.

44. Hypecoum L.

Protandrous pollen flowers, usually yellow in colour, with large inner petals which conceal the pollen in a pouch. As regards flower-pollination they resemble the Papavereae. Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 178, 182) regards them as nectar flowers.

146. **H. pendulum** L.—F. Hildebrand (Jahrb. wiss. Bot., Leipzig, vii, 1869–70) states that the two inner of the four petals are provided with a pair of lateral ligules, while the middle part (the actual petal) alters greatly in form during the course of development. The anthers dehisce extrorsely before the flower opens, so that the pollen is received by the inner petals, which at this stage are folded inwards in the form of a spoon. Next the empty anthers shrivel and contract, and the spoon-like petals form a case which completely encloses the pollen. When the flower expands the pollen-pouches open if pressed from above, so that an insect alighting upon one of them must dust its under-surface with pollen.

During this first stage the stigma is still not quite mature, but after a time the style elongates so as to project beyond the pouches of the petals, and a pollen-covered insect alighting upon the flower must necessarily dust the stigmatic papillae, which are now well developed. Failing insect-visits, the tips and edges of the pollen-pouches curve somewhat outwards, so that the pollen—if it has not already been removed by insects—is brought into such a position that it can readily fall on the stigma if the plant is shaken, or may be carried to it by the wind. Kerner says that the flowers do not open in bad weather, and that in the closed condition automatic self-pollination (pseudo-cleistogamy) takes place.

147. **H. procumbens** L.—Kerner states that the flowers of this species also remain closed in unfavourable weather.

148. **H. grandiflorum** L.—Hildebrand asserts that this species is almost always infertile when the stigma is dusted with pollen from the same flower, or another flower of the same plant.

45. Diclytra DC.

Homogamous bee flowers, the nectar of which is usually secreted and concealed in two pouches, one at the base of each semi-cordate outer petal.

149. **D. spectabilis** DC. (Hildebrand, Jahrb. wiss. Bot., Leipzig, vii, 1869–70; Herm. Müller, 'Fertilisation,' pp. 95–6; Knuth, 'Bloemenbiol. Bijdragen.')—The peduncles are so thin and flexible that the flowers always hang perpendicularly downwards by their own weight. The two lancet-shaped sepals fall off very early. Each of the semi-cordate petals encloses three stamens, the filaments of which follow the bend of the outer edge of the petal, and together form a groove on their outer side which leads to the nectar.

The end of this groove opens exactly where an aperture is left between the outer petals and the winged bases of the inner ones, i. e. the two grooves begin

at the only two places where there are openings into the interior of the flower. The parts of the filaments projecting from the flower—together with the anthers—lie close together, surrounding the stiff style with its stigma, and they themselves are covered with a hood formed by the fusion of the tips of the two inner petals.

Some considerable time before the flower opens the anthers dehisce, discharging their pollen upon the large lobed stigma—which is already mature—and there the pollen lies surrounded by the hood. Automatic self-pollination would therefore be inevitable, and the pollen could never escape from its close envelope, were not crossing effected by insects, which in this case are exclusively bees. When a bee hangs on to the flower to suck nectar, it must push aside the hood and the flexible stamens this encloses with the under-side of its body, and—with the hairs on its ventral surface—sweep off the pollen from the stigma, which owing to the rigidity of the style is not deflected. As soon as the bee leaves, the hood returns to its former position, and again ensheaths the anthers and stigma. There being two

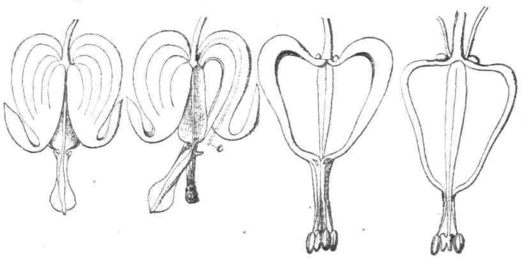

FIG. 23. *Diclytra spectabilis*, *DC.* (after Hildebrand). (1) Flower, natural size. (2) The same after removal of half an outer petal: the hood is pressed aside: the dotted line beginning at *e*, indicates the path of the insect's proboscis. (3) The sexual organs of a bud. (4) The pistil and the two middle stamens of a bud before dehiscence of the anthers.

nectaries, these events happen twice during a visit to each blossom. In younger flowers therefore the pollen on the stigma is removed by the bee, and carried to the stigma of an older flower, which has already been robbed of its own pollen.

VISITORS.—Since the curved channels of Diclytra spectabilis are 18–20 mm. long, there are only two of our native bees which can reach the nectar in the legitimate way, i.e. Bombus hortorum *L.* ♀ (proboscis 20–21 mm. long), and Anthophora pilipes *F.* ♀ (proboscis 19–20 mm.). These two bees are in fact the normal visitors and pollinators of this species. Hermann Müller observed both of them sucking the flowers in Westphalia, and I myself saw B. hortorum doing so in the Kiel Botanic Garden. Bees with a shorter proboscis steal the nectar by biting through the flower. Bombus terrester *L.* ♀—the proboscis of which is 7–9 mm. long—climbs to the upper side of the flower and bites through the petals in the neighbourhood of the nectaries, afterwards extracting the nectar through the hole. Hermann Müller also observed B. pratorum *L.* ♀ (length of proboscis 11–12 mm.), and B. rajellus *K.* ♀ (12–13 mm.), behaving in the same way, while

Osmia rufa *L.* ♀ (9 mm.), Megachile centuncularis *L.* ♂ (6–7 mm.), and Apis mellifica *L.* ☿ (6 mm.), *steal nectar through the holes bitten by humble-bees. Owing to the smoothness of the petals the honey-bee loses a great deal of time while stealing nectar.*

150. **D. eximia** DC.—The flower mechanism essentially agrees with that of the last species, but there is less room for lateral movement of the hood, and the path to the honey is shorter. (Cf. F. Hildebrand, Jahrb. wiss. Bot., Leipzig, vii, 1869–70, pp. 434–6.)

151. **D. cucullaria** DC.—The flower possesses two long-spurred outer petals. Nectar is secreted by two horn-shaped processes of the middle filaments, which project into the spurs. (Cf. Hildebrand, op. cit., pp. 436, 637.)

46. Adlumia Rafin.

The flower mechanism resembles that of the last genus, but there is a larger amount of fusion between the various parts. The pouches of the outer petals are smaller, and the edges of these petals are united together below.

152. **A. cirrhosa** Rafin.—Only the upper part of the hood is well developed and free, while the lower part is fused with the outer petals. The six filaments cohere below into a ventricose tube. (Cf. Hildebrand, op. cit., pp. 437–9.)

47. Corydalis DC.

Homogamous bee flowers. The hood can only be moved downwards. The upper of the two outer petals is prolonged posteriorly into a nectariferous spur.

153. **C. cava** Schweigg. et Kort. (Hildebrand, op. cit.; Herm. Müller, 'Fertilisation,' pp. 97–8; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Knuth, 'Bloemenbiol. Bijdragen.')—The spur of the rose-red or white homogamous humble-bee flowers—which exhale an odour of honey—projects at the back for about 12 mm. beyond the peduncle. A common process of the upper filaments—thickened terminally—extends into it as far as the place where it bends. This process secretes nectar, which is concealed in the downwardly curved end of the spur. The two inner lateral petals are fused together at their tips, and cohere at their bases with the two outer petals. The hood thus formed encloses the anthers and stigma. The latter is large and lobed, and its surface is granular. It is situated on a rigid style, which cannot be bent down, and before the flower opens is covered with the pollen of all the surrounding stamens, which readily adheres to its granular surface. The empty anthers appear only as small appendages of the filaments beneath the stigma. Insects—long-tongued bees—when probing for nectar, must insert their proboscis between the hood and the upper spurred petal. In doing so they press down the hood and—in younger flowers—dust their under-surface with the pollen which has been shed on the stigma, and transfer it to the stigmas of older flowers that have already been robbed of their pollen, thus effecting crossing. When the weight of the insect visitor is removed the hood springs up by elasticity to its original position, and again ensheaths the stigma.

Although the stigma—while within the hood—is surrounded by the pollen of the same flower, automatic self-pollination does not take place. Hildebrand has

proved by numerous experiments that the flowers are quite infertile when pollinated *with their own pollen, and very largely so when geitonogamously pollinated. Xenogamy is necessary for complete fertility.*

VISITORS.—*As*, according to Hermann Müller, the spur extends backwards for 12 mm. from its point of attachment to the peduncle, and the nectar fills only its last 4–5 mm., there is—among the bees which are active when this plant is in flower—only one species (Anthophora pilipes *F.* ♀ and ♂, with a proboscis 19–21 mm. long) that can reach the nectar in the legitimate way. This insect—according to Hermann Müller's observations at Lippstadt and my own at Kiel—visits the flowers so diligently, and in such numbers, that probably none of them remain unfertilized.

Bombus terrester *L.* here makes its appearance as a nectar-thief. It would be just able to reach the beginning of the nectar with its proboscis (7–9 mm. long),

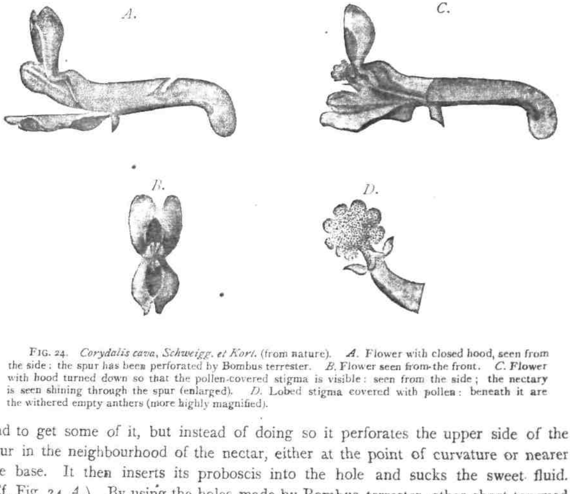

FIG. 24. *Corydalis cava, Schweigg. et Kort.* (from nature). *A.* Flower with closed hood, seen from the side: the spur has been perforated by Bombus terrester. *B.* Flower seen from the front. *C.* Flower with hood turned down so that the pollen-covered stigma is visible: seen from the side; the nectary is seen shining through the spur (enlarged). *D.* Lobed stigma covered with pollen: beneath it are the withered empty anthers (more highly magnified).

and to get some of it, but instead of doing so it perforates the upper side of the spur in the neighbourhood of the nectar, either at the point of curvature or nearer the base. It then inserts its proboscis into the hole and sucks the sweet fluid. (Cf. Fig. 24 *A.*) By using the holes made by Bombus terrester, other short-tongued bees are also able to get the nectar, e.g. the honey-bee (proboscis 6 mm. long), as well as species of Andrena, Sphecodes, and Nomada. The honey-bee certainly sometimes attempts to reach the nectar legitimately, but always fails, owing to the shortness of its proboscis. In making these occasional vain attempts it—and also Anthophora pilipes—effects cross-pollination. Crossing is also brought about if—abandoning the search for nectar—such a bee remains in the flowers to collect pollen. Hermann Müller also observed a few hover-flies (Bombylius major *L.*, and B. discolor *Mikan*, with proboscis of 10 and 11–12 mm. respectively), hovering after

the manner of their kind and sucking nectar legitimately, but the proboscis in these forms is much too slender to be able to effect pollination.

Hoffer observed—in Steiermark—Bombus mastrucatus *Gerst.* ♀, biting through the spur, and stealing nectar.

154. **C. intermedia** P. M. E. (=C. fabacea *Pers.*). (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The flowers are of a dirty purple colour, and arranged in inconspicuous three- or four-flowered racemes. Their mechanism is the same as that of the last species. The spur is about 9 mm. long. As insect-visits are few when the plant is in bloom, and the flowers are frequently broken, there could be only a small production of fruit and seeds were it entirely dependent on cross-pollination. But—so far as Warnstorf was able to observe—each flower sets well-developed fruit, so that the plant must be autogamous should insect-visits fail. Kerner confirms the self-fertility of this species. The pollen is whitish, or yellowish in quantity; the grains are spheroido-tetrahedral, and 37 μ in diameter.

155. **C. solida** Sm. (=C. digitata *Pers.*). (Hildebrand, op. cit.; Herm. Müller, 'Fertilisation,' pp. 98–9; Kirchner, 'Flora v. Stuttgart,' p. 280; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 187–8; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bloemenbiol. Bijdragen.')—The flowers agree in structure with those of C. cava, but the spur is sometimes rather shorter.

The bright violet flowers are arranged in many-flowered racemes, being therefore very conspicuous. The two lateral petals which form the hood are—according to Warnstorf—beset with large forked papillae at the place of fusion, and also along the whole keel. These increase the friction, and are supposed to prevent the insect's feet from slipping so much as they would otherwise do. Hildebrand also states that this species is self-sterile.

Visitors.—The normal visitor and pollinator is again Anthophora pilipes; here too Bombus terrester and Apis mellifica get at the nectar by making perforations; while—as in C. cava—the species of Bombylius suck nectar legitimately without benefiting the flower. Loew also observed—in the Berlin Botanic Garden—Anthophora and Apis.

156. **C. nobilis** Pers.—Hildebrand says that this species resembles C. cava as regards the mode of pollination.

157. **C. capnoides** Pers.—According to Hildebrand, this has a similar flower mechanism, but the form of the outer petals is somewhat different, especially that of the upper petal, the spur of which is curved inwards upon the peduncle. Kerner asserts the species to be self-fertile.

Visitors.—Loew—in the Berlin Botanic Garden—noticed the honey-bee, skg.

158. **C. ochroleuca** Koch. (Hildebrand, op. cit.)—This species is distinguished from the preceding ones in which the hood springs up after the weight of the visiting insect has been removed, by the fact that when this structure has once been displaced it does not return to its original position, but remains inclined downwards, while the stamens and pistil—just as in Medicago sativa—give a jerk like a liberated spring, and conceal themselves in an excavation of the upper petal. It follows that each flower can only once be visited so as to affect the stamens and stigma. The visiting bee dusts its under-surface with pollen from the stigma,

and if it has come from another flower of the same species effects cross-pollination. This plant—according to Hildebrand's experiments—is self-fertile. Kerner confirms the fact of autogamy in the absence of insect-visits.

159. **C. lutea** DC. (Hildebrand, op. cit.; Herm. Müller, 'Fertilisation,' p. 99, 'Weit. Beob.,' I, p. 324.)—The flower mechanism essentially agrees with that of the last species.

Visitors.—Herm. Müller—at Lippstadt—observed Bombus agrorum *F.* ♀, skg. legitimately, and he also saw the following bees at Jena.—

1. Anthophora aestivalis *Pz.* ♀ and ♂, skg.; 2. Bombus confusus *Schenck* ♀, skg.; 3. B. lapidarius *L.* ♀, skg.; 4. B. pomorum *Pz.* ♀, skg.; 5. B. rajellus *K.* ♀, skg.; 6. Eucera longicornis *L.* ♀, skg.; 7. Halictus xanthopus *K.* ♀, skg., or at least attempting to do so; 8. Osmia aurulenta *Pz.* ♀, skg.; 9. Psithyrus rupestris *F.* ♀, skg.

Schenck—in Nassau—observed the following bees skg.:—Osmia cornuta *Ltr.*, and Podalirius acervorum *L.* In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 10) a humble-bee was noticed.

160. **C. acaulis** Pers.—Kerner states that the flower mechanism of this plant resembles that of the last species.

161. **C. bracteata** Pers., and 162. **C. kolpakowskiana** Regel.—

Visitors.—Loew observed—in the Berlin Botanic Garden—Anthophora pilipes *F.* ♀, skg.

163. **C. claviculata** DC. (Knuth, Bot. Centralbl., Cassel, lii, 1892, pp. 1–2; Hart, Nature, London, x, 1874, p. 5.)—The inconspicuous whitish flowers are only 6–8 mm. long and 2 mm. broad, and are arranged in racemes with few (at most six) flowers. They are homogamous. The stamens are at first rather shorter than the style, so that self-pollination can only occur when the pollen is discharged into the dark lilac hood which ensheaths the stigma. The hood when pressed down does not return to its original position: the stigma remains concealed under the folded plate of the inner upper petal. The smallness of the flower makes an exact study of its mechanism difficult.

Visitors.—I have not observed any, but have seen traces of the activity of nectar-sucking insects. In many flowers the connection between the spurred petal and the three others had been forcibly severed, so that these latter must have formed a convenient platform for bees. Willis ('Fls. and Ins. in Gt. Britain,' Part 1) noticed the following near the south coast of Scotland.—

Hymenoptera. *Apidae*: 1. Bombus agrorum *F.*, freq., skg.; 2. B. terrester *L.*, skg.; both effecting pollination. Every flower appears to set fruit.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 10) there have been observed,—Apis, 4 humble-bees, a short-tongued bee, and a Muscid.

48. Fumaria L.

Homogamous bee flowers. The nectar is secreted by a short process from the upper filament. It is concealed in a short rounded pouch of the upper petals. The other arrangements are as in Corydalis.

164. **F. officinalis** L. (Hildebrand, op. cit., p. 450; Herm. Müller, 'Fertilisation,' pp. 99–100; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 188–90;

Kirchner, 'Flora v. Stuttgart,' p. 281; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 23.)—The dull purple flowers are coloured blackish-red at the tip. The flower mechanism agrees with that of Corydalis cava. Owing to the smallness of the flowers, the lateness of the flowering time, and the concealed habitat, insect-visits are few. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) believes that cross-pollination by bees or humble-bees is barely possible, as forcible removal of the upper petal from the two lateral ones—which are united at their tip, and enclose the sexual organs—very easily breaks off the style at its base, for it is not elastic and yielding as in Corydalis. According to the same authority (op. cit., xxxvi; 1895), the pollen-grains are whitish, spheroidal, and smooth, with large projecting germinating processes, and 56–62 μ in diameter. As the flowers, in spite of the scarcity of insect-visits, almost all set fruits even in continuously rainy weather, which

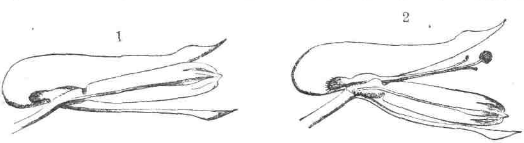

FIG. 25. *Fumaria officinalis, L.* (after Hildebrand). (1) Flower seen from the side (enlarged). (2) The same after removal of half the upper petal, and depression of the inner ones.

entirely prevents visits from bees, there can be no doubt that the inevitable automatic self-pollination is effective.

VISITORS.—Herm. Müller in Westphalia, and myself at Kiel and Föhr, observed the honey-bee visiting the flower and transferring pollen: Warnstorf noticed a humble-bee, but does not mention the species. In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 9) a butterfly was observed.

165. **F. capreolata** L., and 166. **F. parviflora** Lam.—Hildebrand (op. cit.) states that the flower mechanism is quite similar to that of F. officinalis, except that the hood is so feebly elastic that after pressure from above, it either does not regain its original position above the sexual organs or does so but slowly. Both species are capable of autogamy. Moggridge noticed a long-tongued bee (Osmia) visiting the variety *pallidiflora* of F. capreolata *L.*, which is indigenous in the west and south of Europe. In this case the flowers are white before fertilization, but afterwards become rose-red or even carmine-red. This remarkable change of colour in the fertilized flowers may probably be explained as an adaptation for increasing the conspicuousness of the whole inflorescence, and for enabling the highly specialized visitors to recognize and avoid such flowers as being devoid of nectar. Similar phenomena are met with in Ribes aureum and R. sanguineum, Weigelia rosea, Melampyrum pratense, and others (cf. vol. i, pp. 85–6).

167. **F. spicata** DC.—According to Hildebrand (op. cit.), the flower mechanism of this species agrees with those of Corydalis lutea and C. ochroleuca. The column formed by stamens and pistil when liberated from the hood, springs up by the elasticity of the upper filament, and places itself in the sheltering excavation in the upper petal. This species is also fertile with its own pollen.

IX. ORDER *CRUCIFERAE* JUSS.

LITERATURE.—Herm. Müller, 'Fertilisation,' pp. 100–14; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 24.

The Cruciferae are all entomophilous, and most of them are homogamous. By elongation of the floral axis the inflorescence, which is usually an umbel to begin with, becomes a raceme, that renders the plant more or less conspicuous according to the size and number of the flowers. But few species of this order, however, are so conspicuous that insect-visits are very numerous. It follows that almost all Cruciferae are capable of automatic self-pollination.

The calyx not only protects the developing flower, but in many cases holds the claws of the petal together in such a way that they form a short tube at the bottom of which the nectar lies. Insects are attracted by the petals, which are usually yellow or white, more rarely violet, blue, or red. In spite of marked uniformity in the structure of their flowers, the Cruciferae present so much diversity in the number and position of the nectaries, in the relation of the stamens to these and to the stigma, as well as in the mode of storing and concealing nectar, that hardly any two species completely agree in all these details.

The number and position of the nectaries have been investigated very thoroughly by J. Velenovský. His researches were made on 170 species, including all the European Cruciferae and a few exotic forms. He gives drawings of the anterior and lateral aspects of the nectaries in 123 species (belonging to fifty-five genera). According to him, no species is devoid of them. When a stamen is reduced, the nectary develops into a rounded swelling. The size of these organs is usually proportionate to the size of the flower, but to this there are exceptions. Heliophila amplexicaulis, for instance, has much smaller flowers than Malcolmia maritima, yet its nectaries are much larger than those of the latter. The largest upper nectaries are found in Crambe maritima: the smallest in Stenophragma thalianum, and Lepidium ruderale. The lower nectaries—i. e. those at the bases of the short stamens—are always present, though in many cases they may be small, or even almost vestigial, as in Crambe maritima and C. cordifolia. The upper nectaries, on the other hand, are very frequently absent, and some species of a genus may possess them, while they are lacking in others. The position of these organs has special relation to the structure and form of the fruits.

Velenovský groups the Cruciferae with reference to the structure of the nectaries as follows.—

I. Siliquosae.

Upper and lower glands always present, usually with distinct lateral ridges.

1. **Cheirantheae.** Only the lower nectaries are free anteriorly and posteriorly. (Cheiranthus, Matthiola, Malcolmia, Hesperis, Chorispora.)

2. **Erysimeae.** Upper and lower nectaries either free, or united by a weak lateral ridge: the lower open anteriorly, closed posteriorly, where they are usually thickened. (Barbaraea, Nasturtium, Armoracia, Roripa, Erysimum, Conringia, Alliaria.)

3. Arabideae. Upper and lower nectaries either connected by a lateral ridge, or quite distinct. The lower are always open posteriorly, and closed anteriorly, where they are usually thickened and modified in various ways. The upper are either simple or compound, and are of various forms. (Cardamine, Dentaria, Arabis, Stenophragma, Turritis.)

4. Sisymbrieae. The lower nectaries embrace the bases of the short stamens in the form of a uniform unbroken pentagonal ring; the upper are represented by a straight transverse ridge, which is connected by a lateral ridge with the lower nectaries. All six stamens are therefore enclosed by a continuous uniformly thickened ridge. (Sisymbrium, Chamaeplium.)

II. Siliculosae.

(*a*) LATISEPTAE.

Only the lower nectaries are developed, and these are always free, i.e. unconnected internally and externally. They are distinctly or approximately three-sided.

1. Alysseae. The lower nectaries open anteriorly and posteriorly, and are without lateral processes. (Schievereckia, Alyssum, Vesicaria, Cochlearia, Draba.)

2. Lunarieae. The lower nectaries are without lateral processes, and either united together into a ring or open posteriorly. (Aubrietia, Lunaria.)

(*b*) ANGUSTISEPTAE.

The upper nectaries are sometimes developed, and resemble the lower ones, with which they are connected by a lateral transverse ridge.

(*α*) Only the lower nectaries are developed. They are three-sided, always open posteriorly, open or closed anteriorly, and usually prolonged into ridges laterally. (Thlaspi, Carpoceras, Capsella, Teesdalea, Aethionema, Eunomia.)

(*β*) Only the lower nectaries are developed. They are prismatic, truncated above, free anteriorly and posteriorly, and not prolonged laterally. (Iberis.)

(*γ*) Either both lower and upper nectaries developed, or only the former, which then occupy the position of the latter, as e.g. in some species of Lepidium and in Coronopus didymus. The lower nectaries are prolonged laterally into a strong ridge, free posteriorly, closed or free anteriorly at their downwardly produced ends. The upper nectaries are simple, and not connected with the lower ones. (Cardaria, Physolepidium, Lepidium, Coronopus.)

III. Nucamentaceae.

The relations of the nectaries are not so constant as in the preceding groups, and the various sections of Biscutella converge towards all of them. Either the lower nectaries only are present, or both lower and upper. The lower ones are either prismatic, in which case the upper are columnar with a terminal pit, or—when they only are developed—are represented by a uniformly thickened annular ridge, open anteriorly or posteriorly, or even at both ends. These lower nectaries are produced laterally into long processes, which are connected with the upper nectaries

when present. The latter may be double, simple, or appear merely in the form of transverse ridges. (Bunias, Ochthodium, Myagrum, Isatis, Peltaria, Neslea, Camelina.)

IV. Brassiceae.

Both lower and upper nectaries are present, and are never united. The lower are prismatic, flat at the top, and inserted at the posterior side of the short stamens. The upper are always simple, either angular and columnar, or irregularly three-sided, and never in the form of a transverse ridge. (Succowia, Erucastrum, Eruca, Diplotaxis, Brassica, Melanosinapis, Sinapis, Moricandia, Rapistrum, Raphanus, Crambe.) (Cf. the abstracts given by Polák in the Bot. Centralbl., Cassel, xii, 1882, pp. 264–6, and xix, 1884, pp. 9–11.)

The position of the nectaries relatively to the anthers is such that insects probing for nectar must come into contact with all or at least some of the latter with one side of their body, and touch the stigma with the other side. The more unfavourable the position of stamens and pistil for this purpose, the more is automatic self-pollination furthered. As regards concealment of nectar, most Cruciferae belong

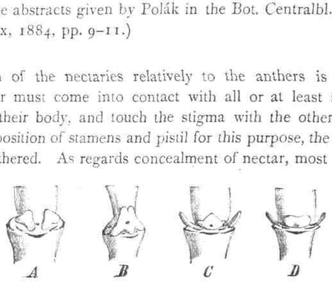

FIG. 26. *Nectaries of some Cruciferae* (after Prantl). Seen rom the side, after removal of sepals, petals, and stamens. *A*. Hesperis Matronalis *L*. *B*. Selenia aurea *Nutt*. *C*. Sisymbrium strictissimum *L*. Brassica Napus *L*.

to the flower class **EC**, a few with vertical sepals (Sinapis, Erucastrum) to **E**, and others, especially those with violet, red, or blue flowers (species of Matthiola, Cakile, Cardamine) to **C**. The last are visited by decidedly more numerous and more highly specialized insects, adapted to effect pollination, than is the case with the white or yellow flowers of Cruciferae belonging to the class **EC**. While these are visited chiefly by flies (especially Syrphidae), by the less specialized bees (Apidae), and to a lesser extent by other Hymenoptera (Sphegidae), as well as by beetles and Lepidoptera, the violet, red, or blue flowers with concealed nectar receive many visits from long-tongued bees and from Lepidoptera. Individual species (Hesperis tristis *L*.) are characteristic Lepidopterid flowers (**L**).

49. Matthiola R. Br.

Conspicuous flowers with deeply concealed nectar, secreted by glands at the bases of the two short stamens.

168. M. incana R. Br. (Knuth, 'Bloemenbiol. Bijdragen,' Bot. Centralbl., Cassel, lxx, 1896, pp. 337–8.)—Homogamous bright red flowers, smelling of cloves. The sepals are erect, and cohere above. They closely surround the claws of the petals, so that these form a tube 15 mm. long and 2 mm. wide, expanding above

to 4 mm. The cordate shape of the base of the calyx indicates even externally the position of the nectaries. The insertion of each short stamen is surrounded by a moderately large swelling that secretes nectar, of which a large drop is produced on each side, so that as much as half the corolla-tube may be filled with it. The four long stamens are surrounded at their bases by a much smaller swelling that does not secrete nectar. The two sepals enclosing them are therefore but slightly gibbous.

The anthers of the four long stamens are placed immediately beneath the opening of the flower, and dehisce by slits about 5 mm. long, which are turned inwards. The anthers of the two short stamens are equally long, but their filaments measure only 2–3 mm., so that they do not reach the stigma, which stands about 8 mm. up the corolla-tube. The four long stamens therefore serve for self-pollination, which is automatically effected by the fall of pollen, or is due to insect-visits. The short stamens—which also dehisce introrsely—serve for cross-pollination: the

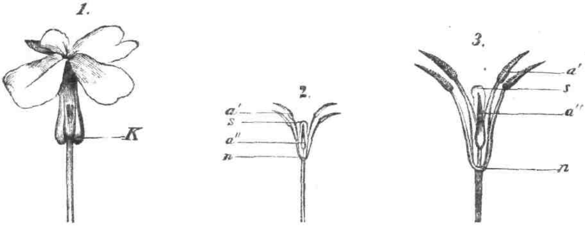

FIG. 27. *Matthiola incana, R. Br.* (from nature). (1) Flower: natural size. *K*, pouch at the base of the calyx. (2) Stamens and pistil after removal of sepals and petals, the stamens spreading; natural size: *a'*, anther of a long stamen; *a''*, anther of a short stamen; *s*, stigma; *n*, the ridge-like nectary surrounding the base of the shorter stamen. (3) Stamens and pistil: twice natural size: references as in (2).

proboscis of an insect endeavouring to get at one of the secreting nectaries, will be dusted with some of the pollen from the adjacent short stamen, and will transfer it to the stigma of another flower of the same species.

VISITORS.—In the garden of the Ober-Realschule at Kiel, I observed a butterfly (Vanessa urticae *L.*) visiting cultivated plants and sucking nectar, and as it visited several flowers in succession cross-pollination must have been effected. The proboscis (14–15 mm. long) of this insect can reach right down into the nectar-secreting base of the flower. In the same place I also noted Pieris sp., skg.

169. M. annua Sweet. (Nobbe, Bot. Centralbl., xxxii, 1887, p. 253; Knuth, 'Bloemenbiol. Bijdragen.')—F. Nobbe observed in cultivated plants that when the seeds germinated very rapidly (3–4 days), most or sometimes all of the flowers were double, but that—on the other hand—plants raised from seeds which germinated slowly usually bore fertile single flowers. The same investigator also found that if a variety of annual stock naturally inclined to produce double flowers was crossed with one chiefly bearing single flowers, the mongrel exhibited the peculiarities of the parent from which pollen was taken, not so much as regards the colour of the

flower—which was intermediate between those of the two parents—but rather in the general form of the raceme, and in the proportion of double flowers to single. Similar experiments have also been made by Schmid, Richter, and Hiltner. Information as to these is published in 'Landwirtschaftliche Versuchs-Stationen,' Berlin, xxxv, Heft 3, 1888.

VISITORS.—I have observed on the species a butterfly (Pieris); and Schletterer—at Pola—noticed Xylocopa violacea *L.*

170. **M. valesiaca** Boiss.—According to Briquet ('Études d. biol. flor. dans les Alpes occident.,' Bul. Univ. Lab. Bot., Genève, i, 1896, pp. 16–78) the throat of the corolla is whitish, while the limbs of the petals are of a dirty violet colour, and spread out to form a surface 30–35 mm. across. At the base of each short stamen there are two secreting nectaries, i. e. four in all. The nectar is concealed in a narrow tube—8–10 mm. deep—formed by the sepals and the claws of the petals, and is sucked by butterflies and also by humble-bees. As the anthers of the four long stamens project above the stigma, these insects chiefly effect self-pollination, more rarely cross-pollination.

171. **M. nudicaulis** (L.) Trautv.—Ekstam says that the diameter of these strongly odorous homogamous flowers is 10–20 mm. in Nova Zemlia, or sometimes as much as 35 mm. The nectaries are at the bases of the short stamens.

This species has only once been found (1827) in Spitzbergen—according to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 32)—so that no new facts are as yet forthcoming as to its time of flowering there.

VISITORS.—Humble-bees have been observed.

50. Cheiranthus L.

Flowers of considerable size, odorous, homogamous, with nectar almost concealed. The nectaries are two swollen ridges at the bases of the two short stamens. The stigma possesses two small recurved plates.

172. **C. Cheiri** L. (Herm. Müller, 'Weit. Beob.,' i, p. 324; Kirchner, 'Flora v. Stuttgart,' p. 285; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.')—The wild plants investigated by Kirchner had bright yellow flowers. From the two nectaries there project outwards to right and left two pointed processes, the nectar secreted by which is stored up in dilatations of the sepals. The anthers dehisce introrsely, and are so situated that they completely close the entrance to the flower. The four upper ones touch the stigma with their lower ends, while the two lower ones do so with their tips. It follows that automatic self-pollination is inevitable. Insect-visitors, however, are more likely to effect cross-pollination, for they touch the stigma and anthers with opposite sides of their proboscis. The flowers of cultivated plants are usually orange- to brownish-yellow.

VISITORS.—Besides the honey-bee, I have observed a hover-fly (Rhingia) visiting the flowers; Hermann Müller also noted Anthophora pilipes *F.* ♀, skg. nectar; and Schenck—in Nassau—saw Andrena flessae *Pz.* Burkill ('Fertlsn. of spring fls.') observed on the Yorkshire coast a humble-bee, Bombus terrester *L.*, skg.

nectar. Schletterer records the following list of visitors noticed in the Tyrol (T.), and at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena albicrus *K.* ♀ and ♂ (T.); 2. A. albopunctata *Rossi*=A. funebris *Pz.*; 3. A. carbonaria *L.*; 4. A. flavipes *Pz.*; 5. A. morio *Brull.*; 6. A. schlettereri *Friese*; 7. Bombus argillaceus *Scop.*, skg.; 8. Eucera longicornis *L.*; 9. Halictus calceatus *Scop.*; 10. H. levigatus *K.* ♀; 11. H. morio *F.*; 12. H. scabiosae *Rossi*; 13. H. villosulus *K.*; 14. Podalirius acervorum *L.*; 15. P. crinipes *Sm.*; 16. P. nigrocinctus *Lep.*; 17. P. retusus *L.* var. meridionalis *Pér.*; 18. Xylocopa violacea *L.* (*b*) *Ichneumonidae*: 19. Bassus laetatorius *F.*; 20. Homotropus tarsatorius *Pz.* The short-tongued bees were undoubtedly only po-cltg.

51. **Nasturtium** R. Br.

White or yellow homogamous flowers, with half-concealed nectar. Nectaries four or six.

173. **N. officinale** R. Br. (Herm. Müller, 'Weit. Beob.,' p. 325, 'Alpenblumen,' p. 153; Kirchner, 'Flora v. Stuttgart,' p. 286; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 24, 148.)—Flowers white. There are two green fleshy nectaries placed close together on the inner side of the base of each short stamen. The short stamens turn their pollen-covered sides towards the stigma, which projects far beyond them. The four long stamens at first reach the level of the stigma, but later on this is higher. They are so turned towards the short stamens that the head or proboscis of an insect probing for nectar must simultaneously touch the stigma and the pollen-covered sides of the three nearest anthers. In rainy weather the flowers remain almost closed, so that automatic self-pollination is effected by the pollen of the long stamens. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) says that the flowers are slightly protogynous; that the longer stamens reach the level of the stigma; and that after the pollen is shed the filaments and anther-lobes become violet in colour.

Visitors.—The following were observed by myself (Kn.) on the island of Föhr, and by Hermann Müller (H. M.) in Thuringia.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes (H. M.). **B. Diptera.** (*a*) *Conopidae*: 2. Physocephala rufipes *F.*, occasional, skg. (H. M.). (*b*) *Empidae*: 3. Empis livida *L.*, very freq., skg. (H. M.); 4. E. rustica *Fallen.* ditto (H. M.). (*c*) *Muscidae*: 5. Ocyptera cylindrica *F.*, skg. (H. M.). (*d*) *Syrphidae*: 6. Eristalis arbustorum *L.*, freq., skg. (H. M.); 7. E. nemorum *L.*, ditto; 8. E. sepulcralis *L.*, ditto (H. M.); 9. E. sp., ditto (H. M.); 10. Helophilus floreus *L.*, in large numbers, skg. and po-dvg. (H. M.); 11. Melithreptus sp., po-dvg. (H. M.); 12. Syritta pipiens *L.* (Kn.), and 13. Syrphus sp. (Kn.), both skg. **C. Hymenoptera.** *Apidae*: 14. Apis mellifica *L.* ☿, skg. (H. M., Kn.); 15. Halictus maculatus *Sm.* ☿, skg. and po-dvg. (H. M.).

Hermann Müller also observed—in the Alps—2 Hymenoptera and 4 Diptera; while MacLeod noticed in Flanders—Apis, and an Eristalis (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 196).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 11) beetles and numerous flies were observed.

174. **N. amphibium** R. Br. (Herm. Müller, 'Fertilisation,' p. 102, 'Weit. Beob.,' i, p. 324; Kirchner, 'Flora v. Stuttgart,' p. 287; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 24.)—Flowers yellow. The six nectaries are placed in the intervals

between the stamens, and are confluent so as to form a ring. The anthers of the four long stamens reach the level of the stigma, those of the two short ones being somewhat lower. In sunny weather the stamens spread out somewhat, and the anthers dehisce introrsely, so that insects probing for nectar necessarily touch the stigma and the pollen with different sides of their head. They therefore effect either cross- or self-pollination. In rainy weather the flowers only half open, so that the anthers of the long stamens come into contact with the stigma—which is at the same level—and automatic self-pollination results.

Warnstorf (Verh. bot. ver., Berlin, xxxviii, 1896) says that the flowers are slightly protogynous. At the time of flowering the stamens project beyond the stigma, over which their anthers incline. During dehiscence these bend outwards at right angles, so that the open loculi with the pollen are turned upwards away from the stigma. Self-pollination is thus rendered difficult and cross-pollination favoured. Between the filaments at the base of the ovary are six small dark-green nectaries. The pollen-grains are yellow, ellipsoidal, densely tuberculated. They are up to 44 μ long and 25–32 μ broad.

VISITORS.—The following were observed by Hermann Müller (H. M.) and myself (Kn.).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes nect-skg. and po-dvg. (H. M.). **B. Diptera.** (*a*) *Empidae*: 2. Empis livida *L.*, skg. (H. M.). (*b*) *Muscidae*: 3. Calobata cothurnata *Pz.* (H. M.); 4. Sp. of Lucilia po-dvg. (H. M.). (*c*) *Syrphidae*: 5. Eristalis arbustorum *L.*, skg. and po-dvg. (Kn., H. M.); 6. Rhingia rostrata *L.*, skg. (H. M.); 7. Syritta pipiens *L.*, skg. (H. M.). **C. Hymenoptera.** *Apidae*: 8. Apis mellifica *L.* ☿, skg. (Kn., H. M.). (*b*) *Pteromalidae*: 9. Pteromalids nect-skg. (H. M.). (*c*) *Tenthredinidae*: (*a*) Allantus arcuatus *Forst.*, skg. (H. M.).

MacLeod—in Flanders—observed Apis, 9 short-tongued bees, a wood-wasp, 5 hover-flies, and 4 other flies (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 198).

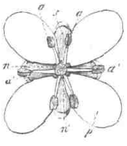

FIG. 28. *Nasturtium sylvestre, R. Br.* (after Herm. Müller). Flower seen from above: in the centre is the stigma covering the ovary; around it are the four larger (*n*) and two smaller (*n'*) nectar-drops; to right and left are the two short stamens (*a'*), anteriorly and posteriorly the two pairs of long stamens (*a*). In all the stamens the pollen-covered surface of the anthers is visible, turned towards the stigma. The filaments are all considerably foreshortened. *s*, sepal; *p*, petal.

175. **N. sylvestre** R. Br. (Herm. Müller, 'Fertilisation,' pp. 100–1, 'Weit. Beob.,' i, p. 324.)—The flower mechanism agrees with that of the last species, but there are four, fleshy, non-confluent nectaries.

Hermann Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Diptera. (*a*) *Bombyliidae*: 1. Anthrax hottentotta *L.*, skg. (Budd.). (*b*) *Empidae*: 2. Empis livida *L.*, skg. (H. M.). (*c*) *Syrphidae*: 3. Chrysogaster macquarti *Loew*, skg. (H. M.); 4. Eristalis arbustorum *L.*, skg. (H. M.); 5. Syritta pipiens *L.*, and 6. Syrphus sp., both skg. and po-dvg. (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 7. Andrena labiata *Schenck* ♀, po-cltg. (H. M.); 8. Apis mellifica *L.* ☿, freq., po-cltg. (H. M.); 9. Halictus nitidiusculus *K.* ♀, skg. (H. M.). (*b*) *Sphegidae*: 10. Crabro wesmaeli *v. d. L.*, skg. (H. M.); 11. Tiphia minuta *v. d. L.*, ditto (H. M.).

Alfken noticed the following *Apidae* at Bremen.—Halictus nitidiusculus *K.* ♀, and Andrena albicans *Müll.* ♀.

MacLeod—in Flanders—saw a humble-bee, 2 hover-flies, and one of the Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 197.)

176. N. palustre DC. (Kirchner, 'Flora v. Stuttgart,' p. 287; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 25, 148.)—The bright yellow petals are only as long as the sepals, so that the flowers are less conspicuous than those of allied species. There are two nectaries at the sides of the base of each short stamen. The anthers of the four long stamens are at the same level as the stigma, while those of the two short ones curve away from it and are somewhat lower. All six dehisce introrsely. The two short stamens are therefore exclusively concerned with cross-pollination, while the four long ones effect automatic self-pollination if insect-visits fail.

Visitors.—I observed—at Föhr—one hover-fly (Eristalis sp.); while MacLeod—in Flanders—noticed 3 insects of the kind (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 197).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 11), Meligethes and 2 Muscidae have been recorded.

177. N. lippiense DC.—

Visitors.—Schletterer observed the following *Apidae* at Pola.—

1. Andrena albopunctata *Rossi*; 2. A. carbonaria *L.*; 3. A. combinata *Chr.*; 4. A. convexiuscula *K.*; 5. A. flavipes *Pz.*; 6. A. nana *K.*; 7. A. parvula *K.*; 8. Halictus calceatus *Scop.*; 9. H. fasciatellus *Schenck*; 10. H. levigatus *K.* ♀; 11. H. morio *F.*; 12. Prosopis clypearis *Schenck*.

178. N. pyrenaicum R. Br. (= Roripa pyrenaica *Reichb.*). (MacLeod, 'Pyreneenbl.')—The yellow flowers have a diameter of 5·5 mm. when expanded. There are four nectaries, of which the two situated between the pairs of long stamens are very small. At the end of flowering, automatic self-pollination is effected by contact of anthers and stigma. Nectar-seeking insects which visit the flowers mainly effect cross-pollination.

Visitors.—MacLeod observed—in the Pyrenees—a short-tongued bee (Halictus), and 2 Muscidae.

52. Barbarea R. Br.

Homogamous yellow flowers with half-concealed nectar. There are six nectaries, of which the pair at the base of each short stamen frequently coalesce.

179. B. vulgaris L. (Herm. Müller, 'Weit. Beob.,' I, pp. 325–6; Kirchner, 'Flora v. Stuttgart,' p. 288; Knuth, 'Bloemenbiol. Bijdragen.')—The golden yellow petals spread out in the sun to a diameter of 7–9 mm. At the base of each short stamen is a small fleshy green nectary on either side, the two often being united into a semicircular ridge. There is also a larger elongated tooth-like nectary outside and between the bases of each pair of long stamens, and corresponding to two short stamens which have disappeared. These last produce only a small drop of nectar, while the four other nectaries—or the two ridges resulting from their union—secrete abundantly in favourable weather. This nectar collects in dilatations at the bases of the two outer sepals, and in such quantity that the stamens—to use Müller's

expression—are placed just as they would be if the two drops of nectar between the pairs of long filaments did not exist. The long stamens—which project above the stigma—make a quarter-turn towards the adjacent short stamens, while these are on the same level as the stigma and remain facing it. In sunny weather the flowers open widely, and the short stamens curve far away from the stigma: when the weather is continuously wet, these stamens effect self-pollination. Insects visiting the flower and trying to get at the larger drops of nectar, chiefly effect cross-pollination.

VISITORS.—Hermann Müller states that—in addition to the honey-bee, also observed by myself—there are the following beetles and flies.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes in large numbers, nect-skg. and po-dvg. (*b*) *Curculionidae*: 2. Ceutorhynchus sp. (*c*) *Scarabaeidae*: 3. Phyllopertha horticola *L.*, gnawing the flower. **B. Diptera.** (*a*) *Muscidae*: 4. sp. of Anthomyia, skg.; 5. Aricia incana *Wiedem.*, skg.; 6. Calobata cothurnata *Pz.*, skg.; 7. Scatophaga merdaria *F.*, skg. (*b*) *Syrphidae*: 8. Ascia podagrica *F.*, po-cltg.; 9. Rhingia rostrata *L.*, freq., skg. and po-cltg.

Leow observed the following Apidae in the Berlin Botanic Garden: 1. Andrena extricata *Sm.* ♀, po-cltg.; 2. Apis mellifica *L.* ☿, skg.; and 3. Bombus lapidarius *L.* ♀, skg. MacLeod—in Flanders—noted 2 bees, a hover-fly, and Empidae (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 194).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 10) Apis, 2 short-tongued bees, 2 Muscidae, 2 hover-flies, and one of the micro-Lepidoptera have been recorded.

180. **B. intermedia** Bor. (Kirchner, 'Flora v. Stuttgart,' p. 288; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 195.)—The flowers are smaller and of a brighter yellow than in the last species. Their diameter is only 6 mm. The flower mechanism resembles that of B. vulgaris, except that there are only four nectaries.

53. Turritis Dill.

Homogamous flowers with half-concealed nectar. Four nectaries.

181. **T. glabra** L. (Kirchner, 'Flora v. Stuttgart,' p. 289; Knuth, 'Bloemenbiol. Bijdragen.')—The flowers are not conspicuous, for the yellowish-white petals are tolerably erect. Two of the four nectaries are situated outside the bases of the two pairs of long stamens: each short stamen is upon a swelling, which is drawn out into a conical process on either side. Not infrequently the four nectaries coalesce into a ring. The anthers dehisce introrsely; those of the long stamens touch the stigma with their lower ends, while those of the short stamens do so with their tips, so that automatic self-pollination is inevitable. Insects probing for nectar may effect either cross- or self-pollination. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes the flowers as being protogynous, the stigmatic papillae maturing even before the flower is fully open, while the anthers subsequently ripen at the same level as the stigma, so that autogamy is rendered possible.

VISITORS.—These are but few; I saw at Kiel only 2 hover-flies (Rhingia rostrata *L.*, and Syritta pipiens *L.*), skg. nectar.

54. Arabis L.

Flowers usually small, seldom of considerable size; white or whitish, rarely rose-red or lilac or blue; generally homogamous, infrequently protogynous. Nectar half-concealed; nectaries 2, 4, or 6.

182. A. alpina L. (Sprengel, 'Entd. Geh.,' p. 333; Axell, 'Om Anord. för Fanerog. Växt. Befrukt.'; Herm. Müller, 'Alpenblumen,' pp. 143–4; Schulz, 'Beiträge,' II, pp. 11–2.)—The flowers are homogamous. Of the four nectaries those outside the bases of the two short stamens are the largest; their nectar collects in the dilatations of the sepals beneath them. The two smaller nectaries outside and between the bases of each pair of long stamens, secrete hardly any nectar. The form of the nectaries is very variable. The long stamens sometimes turn their pollen-covered sides towards the adjacent short stamens, so that an insect probing for nectar must touch them, and therefore cross-pollination is likely to take place. In other cases these stamens turn towards the stigma, and then, especially in dull weather (and always in Greenland), either pollen falls from them on the stigma, or

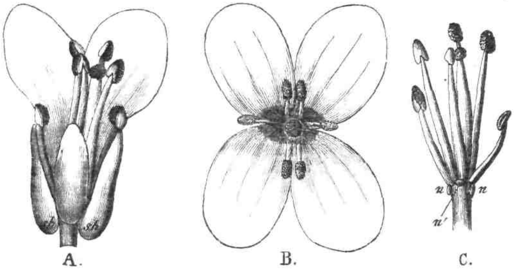

FIG. 29. *Arabis alpina*, *L.* (after Herm. Müller). *A.* Flower after removal of two petals, seen from the side; *sh*, nectar receptacles. Each of the long stamens is turned towards the adjacent short stamen. *B.* Flower seen from above. The pollen-covered sides of all the anthers are turned towards the stigma; the filaments, however, are curved back in such a way that self-pollination does not take place at this stage. *C.* Flower after removal of calyx and corolla: *n*, functional nectaries; *n'*, vestigial nectaries. Stamens are as in *B.* (× 7.)

else this is touched by the anthers, so that automatic self-pollination is effected. In Nova Zemlia, according to Ekstam, the feebly odorous flowers are 6–12 mm. in diameter, and protogynous-homogamous. Nectar is abundantly secreted, and self-pollination is easily possible. (See Fig. 29.)

This species was observed in flower, and bearing young fruits, in Spitzbergen on July 29, 1896 (Anderson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 34).

VISITORS.—Herm. Müller observed 2 flies in the Alps; while Schulz in the Tyrol also saw various butterflies. MacLeod noticed 2 flies in the Pyrenees; and Loew—in the Berlin Botanic Garden—saw the hive-bee sucking nectar.

183. A. Hookeri Lange.—This species is native only to West Greenland and Arctic America. The white petals are as much as 5 mm. long, and project beyond

the calyx, of which the upper part is purple in colour. The plant is apparently biennial (see Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 27–8).

184. **A. pauciflora** Garcke (=A. brassicaeformis *Wallr.*, Brassica alpina *L.*). (Schulz, 'Beiträge,' II, p. 11.)—The white flowers are homogamous. At the base of each short stamen there is a ridge-like nectary, and at the base of each pair of long stamens a small projection. Very little nectar is secreted. The nectaries vary greatly in form. The stigma is usually at the same level as, and in contact with, the bases of the anthers of the long stamens, and therefore automatic self-pollination is inevitable. In favourable weather these anthers turn towards the short stamens, so that insect visitors may effect cross-pollination.

Visitors.—Schulz—in Thuringia—only observed Physopoda and flower-beetles (Meligethes).

185. **A. petraea** (L.) Lam.—Ekstam says that the flowers of Nova Zemlian plants exhale a moderately strong odour of almonds, and are homogamous. Self-pollination is easy.

Visitors.—Ekstam observed a moderate-sized fly in Nova Zemlia.

186. **A. hirsuta** Scop. (Herm. Müller, 'Fertilisation,' p. 102.)—The white flowers are homogamous. Nectar is secreted only by the two nectaries inside the bases of the short stamens. In most flowers the long stamens project beyond the stigma, and therefore autogamy results from the fall of pollen if insect-visits fail. More rarely the anthers of the long stamens are at the level of the stigma, so that automatic self-pollination in effected by direct contact. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) says that the flowers are protogynous, and that the stigma—which matures before the flowers open—projects somewhat beyond the stamens.

Visitors.—Herm. Müller observed the following.—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.*, skg. **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena albicrus *K.* ♂, skg.; 3. Apis mellifica *L.* ☿, skg.; 4. Halictus sexnotatus *K.* ♀, po-cltg. (*b*) *Sphegidae*: 5. Ammophila sabulosa *L.*, skg. **C. Lepidoptera.** *Bombyces*: 6. Euchelia jacobaeae *L.*, skg.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 12) one of the Empidae, 2 Muscidae, and 2 hover-flies have been recorded.

187. **A. arenosa** Scop.—Flowers lilac, or more rarely white.

Visitors.—Buddeberg in Nassau observed a butterfly (Thecla rubi *L.*, skg.), and the following short-tongued *Apidae*.—

1. Andrena albicans *Müll.* ♀, skg.; 2. A. cineraria *L.* ♀, po-cltg.; 3. A. cingulata *F.* ♀ and ♂, skg.; 4. A. nigroaenea *K.* ♀, skg.; 5. A. parvula *K.* ♀, freq., skg. and po-cltg. (12 individuals); 6. Halictus calceatus *Scop.* ♀, skg. and po-cltg.; 7. H. flavipes *K.* ♀, skg.; 8. H. leucopus *K.* ♀, skg. and po-cltg.; 9. H. tetrazonius *Klg.* (quadricinctus *K.* olim) ♀, skg.

Bail (Bot. Centralbl., Cassel, ix, 1882) records the following for West Prussia.—

A. Coleoptera. *Elateridae*: 1. Athius subfuscus *Müll.* **B. Diptera.** (*a*) *Syrphidae*: 2. Eristalis intricarius *L.*; 3. Melanostoma mellina *L.*; 4. Melithreptus scriptus *L.*; and other sp. (*b*) *Muscidae*: 5. Lucilia sp.; 6. Anthomyia sp. **C.**

Hymenoptera. (*a*) *Apidae*: 7. Apis; 8. Andrena nana *K.* (*b*) *Tenthredinidae*: 9. Dolerus vestigialis *Klug*. **D. Lepidoptera.** (*a*) *Noctuidae*: 10. Euclidia glyphica *L.* (*b*) *Rhopalocera*: 11. Pieris napi *L.*; 12. Thecla rubi *L.*; 13. Nemeobius lucina *L.* **E. Hemiptera.** *Pentatomidae*: 14. Eurydema oleraceum *L.*

188. **A. Turrita.** L.—Flowers white.

VISITORS.—MacLeod observed a short-tongued bee (Halictus cylindricus *F.* ♀) in the Pyrenees.

189. **A. sagittata** DC.—

VISITORS.—MacLeod observed a moth (Adela sp.) in the Pyrenees.

190. **A. pumila** Jacq. (Schulz, 'Beiträge,' II, pp. 12–13.)—The white flowers are protogynous in the Tyrol. Outside the base of each short stamen there is a crescentic nectary with two projections. The stigma usually matures in the bud, and frequently protrudes between the petals before the flower opens. At the time of anthesis the style almost always projects about 1 mm. beyond the anthers of the long stamens, and 2–3 mm. beyond those of the short stamens. It is exceptional for the long stamens to reach the level of the stigma. It follows that automatic self-pollination is practically excluded. Insect visitors chiefly effect cross-pollination. Schulz observed gyno-monoecism.

VISITORS.—Schulz saw three small Diptera visiting the flowers in dull weather.

191. **A. bellidifolia** Jacq. (Herm. Müller, 'Alpenblumen,' pp. 144–5.)—The white flowers are protogynous with persistent stigmas. At the base of each short stamen there is a green muriform fleshy nectary secreting abundant nectar; there is also a little knob outside the base of each long stamen. The anthers of the long stamens are at the same level as the stigma, and in dull weather they remain facing it till they dehisce, and effect self-pollination: but in sunny weather these stamens move outwards away from the stigma, so that an insect visitor may effect cross-pollination.

VISITORS.—Herm. Müller only observed a hover-fly (Eristalis tenax *L.*).

192. **A. alpestris** Reichb.—

VISITORS.—Hermann Müller observed the following in the Alps; the honey-bee, 2 butterflies, 2 hover-flies, and 2 Muscidae ('Alpenblumen,' p. 145).

193. **A. caerulea** Haenke. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. I, II, pp. 192, 335; Kirchner, 'Beiträge,' p. 20; Schulz, 'Beiträge,' II, p. 13.)—The flowers are at first blue, but afterwards become pale. They are homogamous or slightly protogynous. Outside the bases of the short stamens there are nectaries which are often very insignificant. Others—resembling these but non-secreting—are situated at the bases of the long stamens. The anthers of the long stamens are at the same level as the stigma, to which they approximate in dull weather and at night, and the anthers of the short stamens not infrequently reach the stigma. Automatic self-pollination is therefore inevitable. Kerner asserts that in continuously rainy weather this takes place within the still unopened flowers, which are therefore pseudo-cleistogamous.

VISITORS.—A few flies have been observed.

194. **A. Holboellii** Hornem.—The flowers are of considerable size, and Warming describes them as homogamous. The anthers of the long stamens at

first project beyond the stigma, but consequently come into contact with it, as a result of growth of the style.

195. A. albida Stev.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella septempunctata *L.* **B. Diptera.** *Syrphidae*: 2. Cheilosia sp., po-dvg.; 3. Eristalis aeneus *Scop.* **C. Hymenoptera.** *Apidae*: 4. Andrena parvula *K.* ♂, skg., ♀, skg. and po-cltg.; 5. Apis mellifica *L.* ☿, skg.; 6. Bombus hortorum *L.* ☿, skg.; 7. B. lapidarius *L.* ♀, skg.; 8. Osmia rufa *L.* ♂, skg. **D. Lepidoptera.** *Rhopalocera*: 9. Vanessa urticae *L.*, skg.

196. A. deltoides DC.—

Visitors.—Loew observed a long-tongued bee (Osmia rufa *L.* ♀), skg. and po-cltg., in the Berlin Botanic Garden.

197. A. caucasica Willd.—

Visitors.—Burkill ('Fertlsn. of spring fls.') observed—on the coast of Yorkshire—one of the Syrphidae, Eristalis pertinax *Scop.*, freq., skg.

55. Cardamine L.

Flowers homogamous or protogynous, white or lilac in colour, with half-concealed or completely concealed nectar. Nectaries 2 or 4.

198. C. pratensis L. (Sprengel, 'Entd. Geh.,' p. 331; Herm. Müller, 'Fertilisation,' pp. 102–4, 'Weit. Beob.,' I, p. 326; Kirchner, 'Flora v. Stuttgart,' pp. 290–1; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 25, 148.)—The white or lilac flowers are large and conspicuous, and insect-visits are therefore more numerous than in the case of most other plants of the order. There are two larger nectaries at the bases of the two short stamens, and two other smaller ones—one outside the bases of each pair of long stamens. The nectar secreted by these four glands collects in the swollen bases of the sepals, and the pouches of the two sepals beneath the larger and more vigorously secreting nectaries are proportionately larger than those of the sepals beneath the two smaller nectaries. As Hermann Müller remarks, the position of the two short stamens can be recognized by looking at the under-side of the calyx. The sepals are closely applied to the petals, so that the claws of the latter are held together so as to form a tube several milimetres long, in the bottom of which the nectar is concealed. C. pratensis therefore belongs to the flower class **C**. Even in the bud the long stamens project beyond the stigma. They also make a quarter-turn towards the adjacent short stamens, so that insects probing for nectar touch the stigma and the pollen-covered anthers with opposite sides of their heads. It follows that if they probe the flower first on one side and then on the other self-pollination is effected, but if they work round it cross-pollination may result. The two short stamens always turn the dehisced sides of the anthers towards the stigma. These anthers in many flowers are at a lower level than the stigma, or they may be at the same or a higher level. In the last two cases automatic self-pollination is possible. During cold rainy weather the rotation of the long stamens is either slight or does not take place at all, so that pollen falls upon the stigma. Yet according to Hildebrand (Ber. D. bot. Ges., Berlin, xiv, 1896), the

plant is self-sterile. Warnstorf says that the flowers are protogynous, and that the stigmatic papillae mature in the still unopened flower.

In the plants studied by Warming in Greenland, the anthers of the short stamens are so close to the stigma that automatic self-pollination is possible; ripe fruits, however, are seldom formed, and propagation is effected vegetatively by bulbils.

In Nova Zemlia—according to Ekstam—the diameter of the faintly odorous, protogynous-homogamous flowers is 10–15 mm.; while Kjellman states that it is usually 24 mm. in Arctic Siberia. The flowers agree in structure with those on the North Frisian Islands which have been described by me.

This species flowers in Spitzbergen from the middle of July till the middle of September (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 32–3). According to the authorities quoted ripe fruits are formed neither in Greenland (Kolderup Rosenvinge) nor arctic Norway (Norman). Ekstam, however, has seen them in Spitzbergen ('Blütenbiol. Beob. a. Spitzbergen,' p. 19). Andersson and Hesselman regard this as a probable case of parthenogenesis; in two specimens they collected there were, respectively, 95 % and 100 % of pollen-grains incapable of germination. According to Ekstam the flowers are white or bright red—according to Andersson bright violet, with darker veins—attain a diameter of 13–18 mm., and are slightly fragrant. The sexual organs are mature at the time the flowers open.

VISITORS.—Ekstam saw a small fly in Nova Zemlia. No visitors have been seen in Spitzbergen.

The following have been observed by Hermann Müller (H. M.), and myself (Kn.).—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes sp., freq., nect-skg. (H. M., Kn.). (*b*) *Staphylinidae*: 2. Omalium florale *Payk.*, extremely freq. (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 3. Bombylius discolor *Mg.*, skg. (H. M.); 4. B. major *L.*, skg. (H. M.). (*b*) *Empidae*: 5. Empis opaca *F.*, skg. (H. M.). (*c*) *Muscidae*: 6. Anthomyia sp., po-dvg. (H. M., Kn.). (*d*) *Syrphidae*: 7. Eristalis nemorum *L.*, po-dvg. (H. M.); 8. Helophilus pendulus *L.*, skg. (H. M., Kn.); 9. Melanostoma mellina *L.*, po-dvg. (H. M.); 10. Rhingia rostrata *L.*, freq., skg. and po-dvg. (H. M.); 11. Syrphus nitidicollis *Mg.*, skg. and po-dvg. (H. M.); 12. S. sp. (Kn.). **C. Hymenoptera.** *Apidae*: 13. Andrena cineraria *L.* ♀, one individual, po-cltg. and skg. (H. M.); 14. A. dorsata *K.* ♀, skg. and po-cltg. (H. M.); 15. A. gwynana *K.* ♀, one individual, po-cltg. (H. M.); 16. A. parvula *K.* ♀ and ♂, po-cltg. and skg. (H. M.); 17. Apis mellifica *L.* ☿, very freq., po-cltg. or skg. (H. M., Kn.); 18. Bombus terrester *L.* ♀, skg. (H. M., Kn.); 19. Halictus cylindricus *F.* ♀, po-cltg. and skg. (H. M.); 20. Nomada lateralis *Pz.* ♀, skg. (H. M.); 21. N. lineola *Pz.* ♂, skg. (H. M.); 22. Osmia rufa *L.* ♂, skg. (H. M.). **D. Lepidoptera.** *Rhopalocera*, skg.: 23. Anthocharis cardamines *L.* (H. M.); 24. Pieris brassicae *L.* (H. M.); 25. P. napi *L.* (H. M., Kn.); 26. Rhodocera rhamni *L.* (H. M.); 27. Vanessa urticae *L.* (Kn.). **E. Thysanoptera.** 28. Thrips, skg. and po-dvg. (H. M.).

Alfken noticed the following in Bremen.—*Apidae*: 1. Bombus derhamellus *K.* ☿, skg.; 2. B. pomorum *Pz.* ♀, skg.; 3. Nomada succincta *Pz.* ♀, skg. Also a butterfly, Thecla rubi *L.*, skg. Rossler saw a hawk-moth, Macroglossa fuciformis *L.*, at Wiesbaden.

In Dumfriesshire (Scott-Elliott, 'Flora of Dumfriesshire,' p. 13), one of the Bibionidae, a Muscid, 4 hover-flies, and a Lepidopterid have been recorded.

H. de Vries (Ned. Kruidk. Arch. Nijmegen, 1875)—*in the Netherlands*—observed a bee, Halictus quadricinctus *F.* ♀; and MacLeod—in Flanders—noticed 8 bees, 11 flies, 4 Lepidoptera, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 192–3).

199. **C. amara** L. (Ludwig, D. bot. Monatschr., Arnstadt, vi, 1888, p. 5; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 193–4; Kirchner, 'Flora v. Stuttgart,' p. 291; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1296; Knuth, 'Bloemenbiol. Bijdragen.')—The nectaries are as in C. pratensis. The flowers are narrowed like a funnel below: they therefore belong to the flower class **C.** The six stamens are almost of the same length, and diverge, the pollen-covered sides of their anthers facing inwards. The pistil is barely half as long as the stamens (according to Warnstorf it is of the same length). Insects probing for nectar touch the anthers and stigma with opposite sides of their heads, so that cross-pollination is usually effected. Self-pollination results only when they suck nectar first on the right and then on the left side of the pistil. Besides hermaphrodite flowers inflorescences bearing small female ones have been observed.

Visitors.—In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 12), flies, Lepidoptera, and beetles have been recorded.

200. **C. impatiens** L. (Herm. Müller, 'Weit. Beob.,' I, p. 327; Kirchner, 'Flora v. Stuttgart,' p. 292.)—The white petals are very small or else absent, so that the flowers are inconspicuous. There is a nectary at the base of each of the long pairs of stamens, and also one at the base of each short stamen. They are united outside the filaments by a prominent ridge. The stamens diverge widely outwards, and their pollen-covered sides face inwards so that insects probing for nectar are likely to effect cross-pollination.

Visitors.—Buddeberg—in Nassau—observed a bee, Andrena albicans *Müll.* ♀, skg. nectar and po-cltg.

201. **C. hirsuta** L.—Jordan states that the anthers are applied to the stigma, so that automatic self-pollination is inevitable.

Visitors.—MacLeod—in Flanders—observed a short-tongued bee, a Muscid, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 193).

In Dumfriesshire (Scott-Elliott, 'Flora of Dumfriesshire,' p. 14), a beetle, a hover-fly, and 2 Muscidae were recorded.

202. **C. latifolia** Vahl.—The lilac flowers have concealed nectar.

Visitors.—MacLeod observed 2 butterflies in the Pyrenees.

203. **C. bellidifolia** L.—In Greenland—according to Warming—the flowers are autogamous, the anthers being for some time closely opposed to the stigma.

Ekstam states that in Nova Zemlia the odourless flowers are protogynous-homogamous, and self-pollination is inevitable. According to Kjellman their diameter in Arctic Siberia is 8 mm.

This species flowers in Spitzbergen from the end of June to the end of August: at the end of this period ripe fruits have been observed; the pollen is abundant and normal (Andersson and Hesselman, op. cit., pp. 33–4). The homogamous flowers are faintly odorous, and have a diameter of 5–7 mm. (Ekstam, op. cit., p. 19).

Visitors.—None were observed in Spitzbergen.

204. **C. resedifolia** L.—Schulz ('Beiträge,' II, pp. 13–14) says that automatic self-pollination is inevitable in the homogamous flowers.

VISITORS.—Herm. Müller saw 6 flies (Muscidae, Syrphidae, Empidae) and a butterfly in the Alps.

205. **C. alpina** L.—According to Kerner this species is protogynous. The stigma projects from the opening flower, the stamens being still immature, so that at this stage pollination can only be effected by the agency of insects. Automatic self-pollination is possible later on when the stamens elongate.

206. **C. chenopodifolia** L.—Grisebach states that in this species there are subterranean cleistogamous flowers in addition to the open flowers above ground.

56. Dentaria Tourn.

Flowers of considerable size, whitish or reddish, usually with concealed nectar. As a rule there are four nectaries.

207. **D. enneaphylla** L. (Schulz, 'Beiträge,' II, p. 14.)—The whitish-yellow petals are 13–17 mm. long. Outside the base of each short stamen there is a crescentic outwardly directed ridge, and at the middle of the bases of each pair of long stamens a broad process projecting upwards. These four nectaries secrete an insignificant amount of nectar. The anthers of the long stamens usually project a little above the petals, and are generally at the same level as the stigma—which is frequently mature before anthesis—though in rare cases they are a little lower. As even in warm weather the petals and stamens diverge but little, the anthers are so near the stigma that automatic self-pollination necessarily takes place. The anthers of the short stamens usually reach only to the middle of the long ones, and dehisce at the same time as, or a little later than, the anthers of these. They serve exclusively for cross-pollination.

VISITORS.—Schulz—at Sanmartino and Paneveggio—saw flies and beetles and especially Noctuidae creeping into the flowers.

208. **D. bulbifera** L. (Kirchner, 'Flora v. Stuttgart,' p. 291; Knuth, 'Bloemenbiol. Bijdragen.')—In the large pale lilac, rose-red, or white flowers, there is a nectary outside the base of each short stamen, and one that is usually cleft outside the insertions of the two pairs of long stamens. Sometimes the four nectaries unite to form a ring. Fruits are found only in sunny places where insects visit the flowers; in shady woods the plant is almost always sterile, propagating by dark-violet bulbils produced in the axils of the leaves.

VISITORS.—In spite of much watching I have never seen insects visiting the flowers in the woods near Kiel and Flensburg, and have very rarely noticed fruits.

57. Hesperis L.

The odorous flowers are of considerable size, and their nectar is concealed. They belong to the flower-classes **C** and **L.**

209. **H. matronalis** L. (Herm. Müller, 'Fertilisation,' pp. 108–9; Kirchner, 'Flora v. Stuttgart,' p. 293; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 209; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d.

nordfr. Ins.,' p. 23, 'Bloemenbiol, Bijdragen.')—The large violet flowers exhale a strong odour of violets, especially in the evening. Two large green fleshy nectaries surround the bases of the short stamens, and are especially well developed internally. The nectar collects on either side of the flower between the insertions of the stamens and the base of the pistil. The anthers of the long stamens stand in the throat of the corolla; after dehiscence they grow somewhat and project beyond the flower. When the anthers of the short stamens dehisce, their lower parts come into contact with the stigma, which during anthesis grows so as to project out of the flower. The anthers dehisce introrsely, so that all of them can pollinate the stigma, automatic self-pollination being therefore inevitable. Insects sucking nectar regularly effect cross-pollination, however, for they touch stigma and anthers with opposite sides of their proboscis or head. In the case of those which collect pollen the chances of cross- and self-pollination are equal.

Warnstorf says that the flowers vary from slightly protogynous to homogamous. The pollen-grains are pale yellow, closely and finely tuberculated, and ellipsoidal, measuring up to 37 μ in length and 25 μ in breadth.

VISITORS.—The following have been observed by Hermann Müller (H. M.), Borgstette (B.), Buddeberg (Budd.), and myself (Kn.).—

A. Coleoptera. *Telephoridae*: 1. Anthocomus fasciatus *L.* (H. M.). **B. Diptera.** (*a*) *Stratiomyidae*: 2. Nemotelus pantherinus *L.*, po-dvg. (H. M.). (*b*) *Syrphidae*: 3. Chrysogaster aenea *Mg.*, po-dvg. (B.); 4. Eristalis arbustorum *L.*, po-dvg. (Kn.); 5. E. nemorum *L.*, po-dvg. (H. M., B.); 6. E. pertinax *Scop.*, po-dvg. (Kn.); 7. E. tenax *L.*, po-dvg. (H. M., Kn.); 8. Rhingia rostrata *L.*, very freq., skg. and po-dvg. (H. M., Budd., Kn.); 9. Volucella pellucens *L.* (B.). **C. Hymenoptera.** *Apidae*: 10. Andrena albicans *Müll.* ♀, po-cltg. (H. M.); 11. Apis mellifica *L.* ☿, po-cltg. (H. M., Kn.); 12. Bombus lapidarius *L.* ♀, ditto (Kn.); 13. Halictus leucopus *K.* ♀, po-cltg. (H. M.). **D. Lepidoptera.** 14. Pieris brassicae *L.*, freq., skg. (H. M., Kn.); 15. P. napi *L.*, ditto (H. M., Kn.); 16. P. rapae *L.*, ditto (H. M., Kn.); 17. Vanessa urticae *L.*, skg. (Kn.).

210. H. tristis L. (Herm. Müller, 'Weit. Beob.,' II, pp. 200–2; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 208.)—This species bears homogamous moth-flowers. The petals are of a dirty greenish-yellow, and traversed by a network of delicate dirty grey-green veins. They are therefore not very conspicuous among the foliage, although their spreading limbs are 14–20 mm. long, or even more, and 3–5½ mm. broad. During the daytime there is no marked scent, and scarcely any insect visitors. Between seven and eight o'clock in the evening, however, the blossoms open and exhale a powerful and agreeable odour—of hyacinths, according to Kerner—after the fashion of moth-flowers.

On the inner side of the bases of the short stamens—according to Hermann Müller's account—there are two large green fleshy nectaries, the secretion of which is so abundant that it completely fills on each side the angle between the base of the short stamen, the two adjacent long stamens, and the pistil.

The narrow sepals are 11–15 mm. long. Their basal parts curve slightly outwards, but their upper two-thirds are so closely apposed as to hold the claws of the petals firmly together. At the beginning of anthesis there are thus but one or two narrow passages to the nectar, which are only adapted to the proboscides of Lepidoptera. When the flowers open the pollen-covered anthers of the four

long stamens—which face inwards—are in the throat of the corolla, and the simultaneously maturing stigma is 1–2 mm. beneath them. The stigma expands to right and left, and is longitudinally cleft into two lobes, the narrow ends of which are reflexed. The two short stamens also direct their pollen-covered surfaces towards the middle of the flower, and are so close to the stigma that their tips are at the same level as, and about 1 mm. distant from its reflexed lobes. The one or two narrow nectar-passages run between the end of the pistil and the short stamens, so that the proboscis of a moth probing for nectar must touch the stigma with one side, and the pollen of a short stamen with the other. After the proboscis has been dusted with pollen all round cross-pollination must be effected in every new flower visited. Should insect-visits fail the stigma pushes up between the four long stamens and dusts itself with pollen, effecting automatic self-pollination which—according to Hermann Müller's experiments—is effective, though Hildebrand asserts (Ber. D. bot. Ges., Berlin, xiv, 1896) that the species is self-sterile. In the early stage of anthesis the only use of the long stamens is to keep unbidden guests from the nectar by blocking the entrance of the flower with their anthers.

Visitors.—Agnes Müller—daughter of Hermann Müller—observed the following during a few mild evenings in May.—Three *Noctuidae*:—1. Dianthoecia nana *Hufn.*; 2. Hadena sp.; 3. Plusia gamma *L.*, freq.: also the Geometrid Iodis lactearia *L.*, and the Pyralid Pionea forficalis *L.* In these moths the proboscis is from 11–18 mm. long.

58. Malcolmia R. Br.

Flowers of considerable size, with concealed nectar.

211. M. maritima R. Br.—Kerner says that in this species there are two rows of erect stiff-pointed bristles on the ovary, to prevent any insect from probing for nectar, except in such a way that its proboscis and head touch the pollen-covered anthers and the stigma. The plant is self-fertile according to Hildebrand (Ber. D. bot. Ges., Berlin, 1896).

59. Sisymbrium L.

Small yellowish or whitish flowers, homogamous to slightly protogynous, with half-concealed nectar. Nectaries two, four, or six.

212. S. officinale Scop. (Herm. Müller, 'Fertilisation,' pp. 109–10, 'Weit. Beob.,' II, p. 202; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 26.)—The small bright yellow flowers are only 3 mm. in diameter. There is a nectary on either side the base of each short stamen, and the nectar secreted collects on each side in the angle bounded by a short stamen, a long stamen and the pistil. The dehisced surfaces of the anthers of the long stamens are at first on the same level as, and almost touching, the stigma, both they and it projecting a little from the flower. The two short stamens are meanwhile still concealed within the corolla, but their anthers have also dehisced. All the stamens now grow a little, the long ones stretching beyond the stigma, and inclining together above it, while the short ones—which are now as long as the pistil—diverge outwards to some extent.

An insect visitor may therefore effect either cross- or self-pollination. As insect-visits are few, automatic self-pollination frequently takes place by pollen falling on

the stigma during the second stage of flowering. This self-pollination is effective, according to Comes ('Stud. s. impoll. i. alc. piante').

VISITORS.—Hermann Müller (H. M.) and myself (Kn.) have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., po-dvg. (H. M.). (*b*) *Syrphidae*: 2. Ascia podagrica *F.*, in large numbers, po-dvg. (H. M.). **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.*, skg. (Kn.); 4. Andrena dorsata *K.*, po-cltg. and skg. (H. M.); 5. Halictus morio *F.* ♂, skg. (H. M.). **C. Lepidoptera.** 6. Pieris brassicae *L.*, skg. (Kn.); 7. P. napi *L.*, skg. (H. M., Kn.); 8. P. rapae *L.*, skg. (H. M.).

Alfken noticed the following *Apidae* at Bremen.—1. Prosopis communis *Nyl.* ♀; 2. Eriades nigricornis *Nyl.* ♀. Schletterer saw at Pola the two bees Andrena florea *F.*, freq., skg., and Halictus calceatus *Scop.*; also the fossorial wasp Pemphredon unicolor *F.*, very freq.

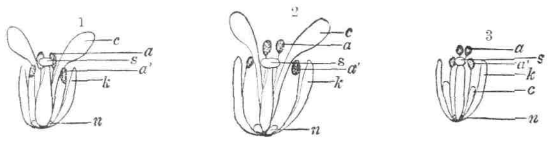

FIG. 30. *Sisymbrium.* (From nature. Semi-diagrammatic, and enlarged.) Two of the long stamens, two petals, and the anterior sepal have been removed. (1) S. officinale *L.* Flower in the first stage; the anthers of the long stamens (*a*) are at the same level as the stigma (*s*), those of the short ones (*a'*) are lower. (2) S. officinale. Flower in the second stage: the anthers of the long stamens project beyond the stigma, those of the short stamens are at the same level. (3) S. Sophia *L.* Flower in the second stage; *k*, calyx; *c*, petal; *n*, nectary.

MacLeod observed 2 bees, 3 hover-flies, and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 199–200).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 14) a Muscid and a hover-fly have been recorded.

213. S. Sophia L. (Kirchner, 'Beiträge,' pp. 20–1; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 200; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 26–7, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 231.)—Although this plant attains a height of 1 m., and possesses a many-flowered inflorescence, it is not very conspicuous, for the diameter of the individual flowers is only 3 mm., and their colour is yellowish-green. The petals are only half as long as the sepals (see Fig. 30), and scarcely differ from them in colour, so that they have almost entirely lost their original function. Stigma and stamens—according to my own investigations—mature simultaneously, and have the same relative position as in the last species. The nectaries are also in the same position, judging from my observations on plants in the North Frisian Islands, though Velenovský figures an irregular swollen nectary covering the entire base of the flower. Kerner states that there is slight protogyny, but that the difference between the times of maturation of stamens and stigma only amount to a few hours. Automatic self-pollination is therefore inevitable. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) describes the pollen-grains as pale yellow, ellipsoidal, very finely papillated or almost smooth, 18–19 μ broad and 25–31 μ long.

Visitors.—I observed the following on the Island of Föhr.—

Diptera. (*a*) *Muscidae*: 1. Anthomyia sp. ♀; 2. Sepsis sp.; 3. Themira minor *Hal.* (*b*) *Syrphidae*: 4. Syritta pipiens *L.*, all skg.

Von Fricken in Westphalia and East Prussia (also Redtenbacher at Vienna) observed the Chrysomelid Colaphus sophiae *Schall.*: and Schiner noted Thereva anilis *L.* in Austria.

214. S. austriacum Jacq.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. Pipiza festiva *Mg.*, skg.; 4. Syritta pipiens *L.*; 5. Syrphus albostriatus *Fall.*, skg. **B. Hymenoptera.** *Apidae*: 6. Andrena dorsata *K.* ♀, skg. and po-cltg.; 7. A. nitida *Fourc.* ♀, po-cltg.; 8. A. propinqua *Schenck* ♀, skg. and po-cltg.; 9. A. tibialis *K.* ♀, skg. and po-cltg.; 10. Apis mellifica *L.* ☿, skg.; 11. Melecta armata *Pz.* ♀, skg.; 12. Nomada lineola *Pz.* ♀, skg.; 13. Osmia caerulescens *L.* ♀, skg. and po-cltg.; 14. O. fulviventris *Pz.* ♂ and ♀, skg.

215. S. orientale L. (=S. Columnae *Jacq.*).—

Visitors.—Friese observed the following *Apidae* at Fiume (F.), Trieste (T.), and in Hungary (H.).—

1. Andrena carbonaria *L.*, not infrequent (F.); 2. A. decorata *Sm.* (H.); 3. A. hypopolia *Pér.* (H., freq. F.); 4. A. limbata *Ev.* (H.); 5. A. morio *Brullé* (F., freq. H.); 6. A. nobilis *Mor.* ♀ and ♂ (H.), not infrequent; 7. A. scita *Ev.* (H.), not infrequent; 8. A. sisymbrii *Friese*, infrequent (F.); 9. A. suerinensis *Friese* (H.), not infrequent; 10. A. tibialis *K.*, 2nd generation (H.); 11. Nomada chrysopyga *Mor.* (H.), freq.; 12. Osmia bisulca *Gerst.* (F., H.); 13. O. fulviventris *Pz.*; 14. O. panzeri *Mor.* (F., H.), freq.; 15. O. solskyi *Mor.* (F.).

216. S. acutangulum DC. (=S. austriacum, var. acutangulum *Koch.*).—

Visitors.—MacLeod—in the Pyrenees—noticed 5 short-tongued Hymenoptera, a Lepidopterid, 3 beetles, 7 hover-flies, a midge, 2 Empidae, and 7 Muscidae (B. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 392–3).

217. S. pinnatifidum DC.—

Visitors.—MacLeod observed Halictus in the Pyrenees (op. cit., p. 393).

218. S. strictissimum L.—

Visitors.—Loew observed the honey-bee skg. in the Berlin Botanic Garden.

60. Stenophragma Čelak.

Flowers small, white, homogamous to slightly protogynous, with half-concealed nectar. There are six nectaries at the insertions of the stamens, but only the two at the bases of the short ones are functional, the other four being vestigial.

219. S. Thalianum Čelak. (=Sisymbrium Thalianum *Gaud.*). (Herm. Müller, 'Weit. Beob.,' II, pp. 202–3; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Kirchner, 'Flora v. Stuttgart,' p. 294; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 27.)—The secretion of the nectaries at the bases of the short stamens collects in the sepals underneath them, but sometimes nectar is absent. The pollen-covered surfaces of the anthers of the long stamens surround the stigma, so that automatic self-pollination is inevitable. Kirchner states that the stamens are variable: as a rule all six are present, the length of the short ones being four-fifths and one-third that of the long ones, but not infrequently both short

ones are absent. Kerner noticed slight protogyny. Warnstorf describes this plant as being homogamous at Ruppin. Hermaphrodite flowers and flowers with aborted stamens are there found on the same plants, i. e. the plants are gyno-monoecious. The pistil of the female flowers is bilateral and reddish-brown. The pollen-grains are whitish, ovoid or ellipsoid, finely granulated, about 30 μ long and 25 μ broad.

VISITORS.—Hermann Müller observed the following.—

A. Coleoptera. (*a*) *Curculionidae*: 1. Centorhynchus sp. (*b*) *Mordellidae*: 2. Anaspis rufilabris *Gyll.* (*c*) *Nitidulidae*: 3. Meligethes. **B. Diptera.** (*a*) *Empidae*: 4. Empis vernalis *Mg.*, skg. (*b*) *Syrphidae*: 5. Ascia podagrica *F.*, po-dvg.; 6. Rhingia rostrata *L.*, skg. **C. Hymenoptera.** *Apidae*: Apis mellifica *L.* ☿, skg.

MacLeod noticed a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 200).

In Dumfriesshire a hover-fly was recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 12).

61. Hugueninia Reichb.

220. **H. tanacetifolia** Reichb. (= Sisymbrium tanacetifolium *L.*).—Flowers homogamous, and smell like honey. Briquet ('Études d. biol. flor. d. les Alpes occident.') says that their diameter is 5 mm. The calyx and the yellow corolla are spreading. The stamens diverge and turn their anthers horizontally with the dehisced side directed upwards. Kirchner adds that in the Botanic Garden at Hohenheim, both petals and stamens are erect, so that the stigma is closely enveloped by the four upper anthers, and automatically self-pollinated. According to Hildebrand (Ber. D. bot. Ges., Berlin, xiv, 1896), the plant is self-sterile.

VISITORS.—Briquet states that these are flies, wasps, bees, and Lepidoptera, which chiefly effect self-pollination.

62. Alliaria Adans.

Small white homogamous flowers, with half-concealed nectar. There are four nectaries, but only the two at the bases of the short stamens are functional—secreting on their inner sides. The two others—between the bases of the long stamens of each pair—do not secrete.

221. **A. officinalis** Andrz. (= Sisymbrium Alliaria *Scop.*). (Herm. Müller, 'Fertilisation,' p. 109, 'Weit. Beob.,' II, p. 202; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 199; Knuth, 'Blütenbiol. Herbstbeob.')—The nectar secreted by the functional nectaries at first forms four drops at the base of the flower between the short stamens and the adjacent long ones, and ultimately fills the space between the bases of the stamens and pistil. As the nectar is secreted inwards, and not towards the sepals, the latter are superfluous after the flower has opened, and readily fall away. All the anthers dehisce introrsely, and those of the long stamens so closely surround the stigma that automatic self-pollination must take place, and according to Hildebrand this is effective (Ber. D. bot. Ges., Berlin, xiv, 1896). Insects, when probing for nectar or devouring or collecting pollen, must sometimes effect cross-pollination owing to the relative position of the anthers and stigma.

Visitors.—The following were observed by H. Müller (H. M.), Borgstette (B.), and myself (Kn.).—

A. Coleoptera. (*a*) *Curculionidae*: 1. A minute sp. of Ceutorhynchus (H. M.). (*b*) *Dermestidae*: 2. Byturus fumatus *F.*, very freq., po-dvg. and skg. (?) (H. M.). (*c*) *Nitidulidae*: 3. Epuraea (H. M.); 4. Meligethes, freq. (H. M.). **B. Diptera.** (*a*) *Bibionidae*: 5. Dilophus vulgaris *Mg.* ♂, skg. (?) (H. M.). (*b*) *Empidae*: 6. Empis nigricans *Mg.*, freq., skg. (H. M.); 7. E. punctata *F.*, skg. (H. M.). (*c*) *Muscidae*: 8. Anthomyia, skg. (H. M.); 9. Sepsis sp. (H. M.). (*d*) *Syrphidae*: 10. Rhingia rostrata *L.*, skg. (H. M.); 11. Syrphus decorus *Mg.* (B.). **C. Hymenoptera.** *Apidae*: 12. Andrena nitida *Fourc.* ♀, skg. (H. M.); 13. Apis mellifica *L.* ☿, skg. (H. M., Kn.).

Rössler noted a Tineid—Adela rufinitrella *Scop.*—at Wiesbaden.

Verhoeff saw the following in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes brassicae *Scop.* (*b*) *Staphylinidae*: 2. Tachyporus obtusus *L.* **B. Diptera.** (*a*) *Muscidae*: 3. Anthomyia sp. (*b*) *Syrphidae*: 4. Platycheirus peltatus *Mg.* one ♂, po-dvg. **C. Lepidoptera.** (*a*) *Tineidae*: 5. Adela cuprella *Thbg.* ♀.

Ducke noted Andrena tscheki *Mor.* ♀ at Trieste.

In Dumfriesshire a beetle, an Empid, 2 Muscidae, and 2 hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 14).

63. Braya Sternb. et Hoppe.

Small yellow or white flowers with half-concealed nectar.

222. B. alpina Sternb. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 248.)—As in Malcolmia, the insects are kept on the right path to the nectar by two groups of erect stiff-pointed bristles on the ovary, with the result that they necessarily touch the pollen-covered anthers with their head or proboscis. The stigma matures before the stamens, and is visible as soon as the petals of the opening bud separate a little. In Nova Zemlia—according to Ekstam—the odourless flowers are homogamous or slightly protogynous-homogamous. Self-pollination is possible.

223. B. purpurascens R. Br.—According to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 34), this species blooms in Spitzbergen from the beginning of July till the end of August, and the fruits apparently ripen during the latter month.

64. Erysimum L.

Flowers yellow, homogamous or protogynous, with half-concealed nectar. Nectaries two or four.

224. E. cheiranthoides L. (Herm. Müller, 'Weit. Beob.,' II, pp. 203–4; Kirchner, 'Flora v. Stuttgart,' p. 295.)—Two of the four nectaries are vestigial, and are situated between the roots of the pairs of long stamens, while the two functional ones are on the inner sides of the bases of the short stamens. These produce so much nectar that it fills on either side the space between the bases of the short stamen, adjacent long stamen, and pistil. All the anthers turn their dehisced pollen-covered surfaces towards the centre, but the short stamens curve outwards, so as to free the approach to the nectar, and make cross-pollination by insect-

visitors possible. The four long stamens surround the stigma and secure automatic spontaneous self-pollination should insect-visits fail.

VISITORS.—Buddeberg—in Nassau—observed a short-tongued bee, Panurgus calcaratus *Scop.*, skg. Loew ('Beiträge,' p. 30) saw Vanessa urticae *L.*, skg., in Silesia. MacLeod—in Flanders—noted a short-tongued bee, a hover-fly, and a Muscid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 198–9).

225. **E. helveticum** DC. (Herm. Müller, 'Alpenblumen,' p. 150.)—Flowers homogamous.

VISITORS.—Müller noticed Muscidae, 3 beetles, and 4 Lepidoptera.

226. **E. orientale** R. Br. (Knuth, 'Blütenbiol. Herbstbeob.') — Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1894) states that the pollen-grains are yellowish-white, ellipsoidal, and tuberculated, 30–37 μ long and 18–21 μ broad.

VISITORS.—In the Kiel Botanic Garden I observed hover-flies (Eristalis sp., Platicheirus sp., Syritta pipiens *L.*, Syrphus balteatus *Deg.*) and Lepidoptera (Pieris napi *L.*); all skg.

227. **E. aureum** Breb.—This species is self-fertile (Comes, 'Stud. s. impoll. i. alc. piante').

228. **E. crepidifolium** Reichb. (Schulz, 'Beiträge,' II, pp. 14–15.)—Flowers bright yellow. The base of each short stamen is surrounded by a quadrangular or polygonal nectar-secreting ridge, and there are three glandular processes directed obliquely upwards in front of the bases of each pair of long stamens, the middle one of the three being immediately opposite the cleft between the two filaments. The stigma is mature immediately after the flower has opened. At first it projects about 3 mm. beyond the long stamens. Subsequently the filaments elongate, the anthers reaching the stigma, but they dehisce very late, so that at first only cross-pollination is possible, and self-pollination can only take place towards the end of anthesis.

VISITORS.—Schulz observed Lepidoptera, bees and flies, as well as numerous small beetles (Meligethes): these probably effect both self- and cross-pollination.

65. Brassica L.

Flowers yellow, and homogamous or slightly protogynous. They are usually aggregated into large inflorescences, being therefore tolerably conspicuous. The nectar is half concealed, and there are four nectaries, of which two are on the inner side of the short stamens, and the others between the insertions of the long stamens of each pair.

229. **B. oleracea** L. (Herm. Müller, 'Fertilisation,' pp. 111–12, 'Weit. Beob.,' II, p. 204; Kirchner, 'Flora v. Stuttgart,' p. 297; Cobelli, Abh. ZoolBot. Ges., Wien, xl, 1890, pp. 161–4; Knuth, 'Bl. u. Insekt. a. Helgoland,' 'Bl. u. Insekt. a. d. nordfr. Ins.,' 'Weit. Beob.,' p. 231.)—Kerner states that the bright yellow flowers are open from eight o'clock in the morning till nine o'clock at night. There are four nectaries, of which two are on the inner side of the bases of the short stamens, and the two others between the insertions of the long stamens of each pair. The drops of nectar secreted by the former spread out on each side between the three adjacent stamens and the ovary, while those secreted by the two others collect on the outside

between the pairs of long stamens, sometimes—says Müller—in such quantity as to touch the sepals outside these. Jordan states, however, that the anterior and posterior nectaries are not functional. The two short stamens are usually not as long as the pistil, though this is sometimes the case: they curve outwards away from it, and in doing so turn the pollen-covered sides of their anthers inwards. The four long stamens remain in the middle of the flower, but make a quarter- or half-turn, so that the pollen-covered sides of their anthers are turned towards the adjacent short stamens, or even completely outwards. I found the wild cabbage of Helgoland to agree with this description of Hermann Müller's. Insects when probing for the nectar secreted by the inner nectaries chiefly effect cross-pollination. The nectar of the other glands can be got at without touching the stigma, so that these are probably useless for pollination, as the observations of Jordan appear to indicate (vide supra). Should insects fail to visit the flowers, the upper parts of the long stamens usually curve so far towards the stigma as to touch it, thus effecting automatic self-pollination. Lund and Kjaerskou (Justs Bot. Jahresber., Leipzig, xiii, (1885) 1887, p. 753) say that this is effective, but the numerous fruits which result do not usually contain so many seeds as those produced by crossing.

VISITORS.—The honey-bee here takes a prominent place. Besides this, I have observed—in Helgoland—another bee—Andrena carbonaria *L.*, skg., corresponding to the flower in size, and—mostly in the same island—the white cabbage-butterfly, Pieris brassicae *L.* On the North Frisian Islands I further noticed various po-dvg. and skg. Syrphidae—Helophilus, Eristalis, Syrphus, Rhingia—and also a humble-bee, Bombus terrester *L.*, skg. A small beetle (Meligethes) is everywhere found po-dvg. and gnawing the petals, usually without benefit to the flower.

Hermann Müller (H. M.) and Buddeberg (Budd.) have observed the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes, very freq., po-dvg. or gnawing the flower (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena fulvescens *Sm.* ♀, po-cltg. (Budd.); 3. A. fulvicrus *K.* ♀, po-cltg. (H. M.); 4. A. nana *K.* ♂, skg. (H. M.); 5. A. gwynana *K.* ♀, skg. and po-cltg. (M. M.); 6. A. nigroaenea *K.* ♀, skg. (H. M.); 7. Apis mellifica *L.* ☿, skg. and po-cltg. (H. M.); 8. Halictus cylindricus *K.* ♀ (H. M.); 9. H. morio *F.* ♀, po-cltg. and skg. (Budd.); 10. Osmia rufa *L.* ♂, skg. (Budd.). **C. Thysanoptera.** 11. Thrips, freq. (H. M.).

Alfken and Höppner (H.) noticed the following at Bremen.—*Apidae*: 1. Andrena albicans *Müll.* ♀, not infrequent; 2. A. humilis *Imh.* ♂ (H.); 3. A. argentata *K.* ♀, rare; 4. A. carbonaria *L.* ♀, infrequent; 5. A. convexiuscula *K.* ♀, infrequent; 6. A. nigroaenea *K.* ♀, not infrequent; 7. A. propinqua *Schenck* ♀ (H.); 8. Bombus agrorum *F.* ♀, infrequent; 9. B. derhamellus *K.* ♀, infrequent; 10. B. sylvarum *L.* ♀, infrequent; 11. Halictus calceatus *Scop.* ♀, very freq.; 12. H. flavipes *F.* ♀, freq.; 13. H. levis *K.* ♀, infrequent; 14. H. minutus *K.* ♀, infrequent; 15. H. nitidiusculus *K.* ♀, freq.; 16. H. punctulatus *K.* ♀, freq.; 17. H. rubicundus *Chr.* ♀, freq.; 18. H. sexnotatulus *Nyl.* ♀, rare; 19. Nomada succincta *Pz.* ♀ and ♂, skg.; 20. Osmia rufa *L.* ♀ and ♂, not infrequent; 21. Podalirius retusus *L.* ♀ and ♂, infrequent.

Leege saw the following *Apidae* on Juist.—1. Colletes cunicularis *L.*; 2. Osmia maritima *Friese* ♂, freq., skg.

Loew observed the following in the Berlin Botanic Garden.—**Hymenoptera**. *Apidae*: 1. Andrena carbonaria *L.* ♂, skg.; 2. A. extricata *Sm.* ♀, po-cltg.; 3. Bombus agrorum *F.* ♀, skg. and po-cltg.; 4. B. lapidarius *L.* ♀, skg.; 5. B. terrester *L.* ♀ and ☿, skg. and po-cltg.; Osmia rufa *L.* ♂, skg.

MacLeod saw in Flanders,—6 long-tongued and 8 short-tongued bees, 8 hover-flies, 2 Muscidae, 3 Lepidoptera, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 204).

Schletterer noted two bees at Pola,—1. Halictus calceatus *Scop.*; 2. H. fasciatellus *Schenck*.

Cobelli (Verh. ZoolBot. Ges., Wien, xl, 1890) observed on the flowers of the variety *sabauda*, 50 Apidae belonging to the genera Andrena, Anthophora, Apis, Bombus, Chalcidoma, Chelostoma, Eucera, Halictus, Melecta, Nomada, Osmia, and Xylocopa; while the later-flowering variety *botrytis-asparagoides* was visited only by eleven species of Apidae, which were also less numerously represented.

230. **B. Rapa** L. (Kirchner, 'Flora v. Stuttgart,' p. 298; Schulz, 'Beiträge,' I, pp. 3–4; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 204–5; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 27–8.)—The golden-yellow, slightly protogynous flowers agree with the last species as regards the number and position of the nectaries, but Kirchner says that the actively secreting ones on the inner side of the short stamens are divided into two tubercles. When the flowers open the anthers are still unripe, and those of the four long stamens lie close to the already mature stigma. Before the corolla has fully expanded the anthers dehisce, and at the same time the filaments make a half-turn so that their pollen-covered sides are directed outwards. Schulz states that in some cases they make only a quarter-turn. The anthers of the short stamens remain with their pollen-covered sides turned towards the stigma, but they are 2–3½ mm. below it. When the flower fades, the long stamens—which project somewhat beyond the stigma—curve a little, so that automatic self-pollination may take place, and according to Kirchner and Hildebrand ('Die Geschlechtsvert. b. d. Pfl.,' p. 70), this is effective, though Lund and Kjærskou ('Morph. Beskriv. af B. oleracea &c.'), as well as Focke, describe the plant as self-sterile. Insects visiting the flowers will, as in the last species, chiefly effect cross-pollination, which results in the production of many seeds.

Visitors.—Besides the honey-bee (skg. and po-cltg.), I have observed the following at Kiel:—po-dvg. hover-flies (Helophilus pendulus *L.*, Syritta, Eristalis tenax *L.*, E. nemorum *L.*, Syrphus), and also the useless guest Meligethes.

Krieger noticed Prosopis communis *Nyl.* at Leipzig.

Schmiedeknecht observed the following *Apidae* in Thuringia.—1. Andrena flessae *Pz.*; 2. A. floricola *Ev.*; 3. A. dorsata *K.*; 4. Osmia bicolor *Schr.* ♀; 5. O. rufa *L.*; and—according to Piccioli—mentions 6. Andrena florentina *Magr.*, for Florence.

Schenck noticed the following *Apidae* in Nassau.—

1. Andrena albicans *Müll.*; 2. A. chrysosceles *K.*; 3. A. cineraria *L.*; 4. A. combinata *Chr.*; 5. A. convexiuscula *K.*; 6. A. extricata *Sm.*; 7. A. flavipes *F.*; 8. A. floricola *Ev.*; 9. A. gwynana *K.*; 10. A. parvula *K.*; 11. A. propinqua *Schenck*; 12. A. punctulata *Schenck*; 13. A. nitida *Fourcr.*; 14. A. trimmerana *K.*; 15. Halictus albipes *F.*; 16. H. interruptus *Pz.* ♀; 17. Nomada alternata *K.*; 18. N. succincta *Pz.*; 19. N. xanthosticta *K.*; 20. Osmia bicolor *Schr.*

231. **B. Napus** L. (Herm. Müller, 'Weit. Beob.,' II, p. 204; Kirchner, 'Flora v. Stuttgart,' p. 299; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 28.)—The mechanism of the golden-yellow slightly protogynous flowers entirely agrees with that of the last

species. Kirchner states, however, that the protogyny is somewhat more pronounced. The anthers—which have a little red spot at the tip—dehisce very soon after the flower opens. The flowers are somewhat larger than in the last species, but owing to the elongation of the axis of the inflorescence, are less crowded.

VISITORS.—I observed the same as in the last species.

Wüstnei saw Andrena carbonaria *L.* in the island of Alsen. Alfken observed the following on B. Napus and B. Rapa at Bremen.—

A. Diptera. *Syrphidae*: 1. Orthoneura nobilis *Fall.*; 2. Platycheirus albimanus *F.*; 3. Syrphus venustus *Mg.*, very freq. **B. Hymenoptera.** *Apidae*: 4. Andrena albicrus *K.* ♀, freq.; 5. A. argentata *Sm.* ♀; 6. A. carbonaria *L.* ♀ and ♂, infrequent; 7. A. cineraria *L.* ♀, infrequent; 8. A. cingulata *F.* ♀, infrequent; 9. A. flavipes *Pz.* ♀, freq.; 10. A. fucata *Sm.* ♀, infrequent; 11. A. nigroaenea *K.* ♀, not infrequent; 12. A. parvula *K.* ♀, very freq.; 13. A. propinqua *Schenck* ♀ and ♂, very freq.; 14. A. tibialis *K.* ♀, infrequent; 15. Eriades florisomnis *L.* ♀ and ♂, infrequent; 16. Halictus calceatus *Scop.* ♀, very freq.; 17. H. flavipes *F.* ♀, freq.; 18. H. leucopus *K.* ♀, infrequent; 19. H. nitidiusculus *K.* ♀, not infrequent; 20. H. rubicundus *Chr.* ♀, freq.; 21. H. sexnotatulus *Nyl.* ♀, infrequent; 22. Nomada bifida *Ths.* ♀, infrequent; 23. N. lineola *Pz.* ♀, skg., infrequent; 24. N. ruficornis *L.* var. flava *Pz.* ♀, infrequent; 25. Osmia rufa *L.* ♀ and ♂, freq.; 26. Podalirius acervorum *L.* ♀, infrequent; 27. P. retusus *L.* ♀ and ♂, freq.

Schmiedeknecht noticed Osmia bicolor *Schr.* ♀, in Thuringia.

MacLeod—in Flanders—observed the following on B. napus and B. Rapa.—Apis, a humble-bee, 6 short-tongued bees, 4 hover-flies, 3 other Diptera, 2 Lepidoptera, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 205).

De Vries saw the bee Andrena dorsata *K.* in the Netherlands.

232. B. nigra Koch. (Kirchner, 'Flora v. Stuttgart,' p. 299; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 205–6; Knuth, 'Bl. u. Insekt. a. Helgoland,' 'Bl. u. Insekt. a. d. nordfr. Ins.')—The strong kumarin odour and the yellow colour of the numerous flowers attract many insects wherever the plant is common, as for instance on the high ground of Helgoland. The yellow sepals project obliquely; the petals are erect; the diameter of the flower is 11–12 mm. As the long stamens are at the same level as and only about 1 mm. from the stigma, pollen can fall upon it when the flowers are bent by the wind, thus effecting automatic self-pollination. The long stamens are turned towards the two short ones, which being 2–3 mm. lower than the stigma, can never effect self-pollination, but serve for cross-pollination. This is brought about by numerous insects, which probe for the nectar secreted in the base of the flower, soon getting dusted with pollen, that they afterwards brush off on the stigma projecting from the middle of some other flower. There are four green nectaries of about the same size, one on the inner side of each short stamen and one on the outer side of each pair of long stamens. They secrete copiously. Kirchner says that on different stocks the styles are of varying length, so that the stigma may be either at the level of the short stamens or of the long ones. I have not observed such variations in Helgoland.

VISITORS.—I observed in Helgoland numerous po-dvg. flies and po-cltg. or nectar skg. bees.—

A. Diptera. (*a*) *Muscidae*: 1. Calliphora erythrocephala, *Mg.*, very freq.; 2. C. vomitoria *L.*, freq.; 3. Coelopa frigida *Fall.*, very freq.; 4. Cynomyia mortuorum *L.* ♂, freq.; 5. Fucellia fucorum *Fall.*, very freq.; 6. Lucilia caesar

L., very freq.; 7. Scatophaga stercoraria *L.* ♀ and ♂, very freq.; 8. medium-sized Muscids. (*b*) *Syrphidae*: 9. Eristalis arbustorum *L.* ♀ and ♂, very freq.; 10. E. tenax *L.* ♀ and ♂, freq,; 11. Helophilus trivittatus *F.* ♀, occasional; 12. Syritta pipiens *L.*, very freq. **B. Hymenoptera.** *Apidae*: 13. Andrena carbonaria *L.* ♂, 2nd brood. **C. Lepidoptera.** *Rhopalocera*: 14. Pieris brassicae *L.*, occasional. **D. Orthoptera.** 15. Forficula auricularia *L.*, very freq., dvg. the flowers. All these insects were observed from July 8 to 11, 1895, on the high ground.

Verhoeff noticed the following in Baltrum.—**A. Coleoptera.** (*a*) *Nitidulidae*: 1. Meligethes brassicae *Scop.* (*b*) *Scarabaeidae*: 2. Phyllopertha horticola *L.* **B. Diptera.** *Muscidae*: 3. Anthomyia sp.

Heinsius saw a Muscid—Scatophaga stercoraria *L.* ♂, and a hover-fly—Eristalis arbustorum *L.* ♀—in Holland (Bot. Jaarb. Dodonaea, Ghent, iv, 1892).

H. de Vries noticed a humble-bee—Bombus subterraneus *L.* ☿—in the Netherlands (Ned. Kruidk. Arch., Nijmegen, v, 1877).

233. **B. fruticulosa** Cyril.—This species is self-fertile (Comes, 'Stud. s. impoll. i. alc. piante').

66. Sinapis Tourn.

Flowers yellow, homogamous or slightly protogynous. In some species the sepals project horizontally, so that the nectar is exposed, but in others it is completely concealed. Four nectaries, situated as in Brassica.

234. **S. arvensis** L. (Herm. Müller, 'Fertilisation,' p. 112, 'Weit. Beob.' II, pp. 204–5; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 28, 149, 'Blütenbiol. Beob. a. d. Ins. Rügen'; Kirchner, 'Flora v. Stuttgart,' pp. 299, 300.)—As the sepals are horizontal the nectaries are visible and accessible from the exterior, but the flowers are so crowded that insect visitors find it more convenient to thrust the proboscis between the stamens to the nectar, and this is their regular practice. The anthers of the long stamens at first turn their dehisced sides towards the adjacent short stamens, but on the third day of flowering direct them upwards, while the filaments curve downwards, so that if the pollen has not been removed by visitors and pollination effected, the stigma, by pushing up between the anthers, will be automatically pollinated. Eggers observed—according to Hansgirg—pseudo-cleistogamy. Jordan says that, as a rule, only the two nectaries opposite the short stamens are functional. According to Kerner the flowers are protogynous. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) describes the pollen-grains as yellow, ellipsoidal, with delicate regular ridges which cross one another.

Visitors.—Herman Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) have observed the following.—

A. Coleoptera. (*a*) *Alleculidae*: 1. Gonodera murina *L.* (H. M.). (*b*) *Cerambycidae*: 2. Leptura livida *F.*, dvg. the anthers (H. M.); 3. Strangalia nigra *L.*, ditto (H. M.). (*c*) *Coccinellidae*: 4. Coccinella septempunctata *L.*, nect.-lkg. (H. M.). (*d*) *Nitidulidae*: 5. Meligethes sp., freq. (H. M., Kn.). (*e*) *Scarabaeidae*: 6. Phyllopertha horticola *L.*, gnawing the flower (H. M.). **B. Diptera.** (*a*) *Conopidae*: 7. Dalmannia punctata *F.*, skg. (H. M.). 8. Myopa buccata *L.*, skg. (H. M.). (*b*) *Empidae*: 9. Empis sp., skg. (H. M.). (*c*) *Muscidae*: 10. Lucilia sp., po-dvg. (H. M.); 11. Scatophaga merdaria *F.* (H. M.). 12. S. stercoraria *L.*, po-dvg. (H. M.). (*d*) *Syrphidae*: 13. Chrysogaster macquarti *Loew*, po-dvg. (H. M.); 14. Eristalis aeneus *Scop.*, skg. and po-dvg. (H. M.); 15. E. arbustorum *L.*, freq.,

ditto (H. M.); 16. E. pertinax *Scop.*, not infrequent, ditto (H. M.); 17. E. sepulcralis *L.*, ditto (H. M.); 18. E. tenax *L.*, ditto (Kn.); 19. Rhingia rostrata *L.*, skg. and po-dvg. (H. M.); 20. Syritta pipiens *L.*, po-dvg. (H. M.); 21. Syrphus umbellatarum *F.*, ditto (Kn.). **C. Hemiptera.** *Pentatomidae*: 22. Eurydema ornatum *L.*, boring into the flower and skg. (Budd.). **D. Hymenoptera.** (*a*) *Apidae*: 23. Andrena albicrus *K.* ♂, very freq., skg. (H. M.); 24. A. cingulata *F.* ♂, skg. (H. M.); 25. A. dorsata *K.* ♀, skg. and po-dvg. (H. M.); 26. A. nana *K.* ♂, skg. (H. M.); 27. Apis mellifica *L.* ☿, freq., skg. (H. M., Kn.); 28. Bombus lapidarius *L.* ☿, skg. (H. M.); 29. Eriades nigricornis *Nyl.* ♂, skg. (Budd.); 30. Halictus leucozonius *K.* ♀, skg. (H. M.); 31. H. malachurus *K.* ♀, skg. and po-cltg. (H. M.); 32. H. sexnotatus *K.* ♀, occasional, skg. (H. M.); 33. H. sexsignatus *Schenck* ♀, occasional, skg. (H. M.); 34. Nomada alboguttata *H.-Sch.* var. pallescens *H.-Sch.* ♀, freq., skg. (H. M.); 35. Prosopis hyalinata *Sm.* ♂, skg. and po-cltg. (H. M.); 36. Prosopis confusa *Nyl.* ♀, ditto (H. M.). (*b*) *Tenthredinidae*: 37. Cephus pygmaeus *L.*, nect.-lkg. and po-dvg. (H. M.). **C. Lepidoptera.** (*a*) *Noctuidae*: 38. Euclidia glyphica *L.* skg. (H. M.). (*b*) *Rhopalocera*: 39. Pieris napi *L.* (H. M.), and 40. P. rapae *L.* (Kn.); both skg.

I noted the following in Helgoland (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 38).—

Diptera. (*a*) *Muscidae*: 1. Calliphora vomitoria *L.*, po-dvg. (*b*) *Syrphidae*: 2. Eristalis tenax *L.*, skg.; and on Rügen: **A. Diptera.** (*a*) *Syrphidae*: 1. Eristalis anthophorinus *Zett.* ♂; 2. E. arbustorum *L.* ♂; 3. E. pertinax *L.*; 4. E. sepulcralis *L.*; 5. E. tenax *L.*; 6. Helophilus floreus *L.*; 7. Syrphus pyrastri *L.*; and 8. S. ribesii *L.*; all skg. and po-dvg. (*b*) *Tabanidae*: 9. Chrysops caecutiens *L.* ♂. **B. Hymenoptera.** *Apidae*: 10. Andrena carbonaria *L.* ♀; 11. Apis mellifica *L.* ☿; 12. Bombus terrester *L.* ☿; and 13. Halictus rubicundus *Chr.* ♀; all skg. and po-cltg. **C. Lepidoptera.** *Rhopalocera*: 14. Vanessa atalanta *L.*; 15. V. urticae *L.*; and 16. Pieris sp.; all skg.

Alfken observed the following in Bremen.—

Apidae. 1. Andrena albicans *Müll.* ♀; 2. A. carbonaria *L.* ♀; 3. A. denticulata *K.* ♀; 4. A. flavipes *Pz.* ♀; 5. Eriades florisomnis *L.* ♀.

Heinsius saw the following in Holland (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, pp. 63–5).—

2 hover-flies—Eristalis arbustorum *L.* ♀, and E. horticola *Deg.* ♀, a butterfly—Pieris brassicae *L.* ♀, a short-tongued bee—Andrena carbonaria *L.* ♀—freq., and 4 long-tongued bees—Podalirius acervorum *L.* ♀, Apis mellifica *L.* ☿, Bombus hortorum *L.* ☿, and B. lapidarius *L.* ☿.

H. de Vries (Ned. Kruidk. Arch., Nijmegen, v, 1877) observed Apis mellifica *L.* ☿: MacLeod records 5 hover-flies, a Muscid, and a Lepidopterid for Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 207): and Schletterer noticed a ruby-wasp—Arge cyanocrocea *Forst.*—at Pola.

235. S. Cheiranthus Mert. et Koch, γ. **montana** DC. (=Brassica montana DC.). (MacLeod, 'Pyreneenbl.')—The claws of the yellow petals are so closely held together by the sepals as to form a tube 9–11 mm. long. The nectar is therefore only legitimately accessible to the thin proboscis of Lepidoptera. Two of the four nectaries—the smaller ones—are always at the bases of the short stamens. The two larger ones are at the bases of the long stamens, but they secrete no nectar and (as in the case of Diplotaxis muralis) may be reached from without by clefts between the sepals. The smaller nectaries, on the other hand, are functional, and can only be reached by two narrow passages at the sides of the stigma. When the thin proboscis of an insect is introduced, it first touches the anthers of the four long

stamens—which have dehisced introrsely, and are somewhat higher than the stigma—and then the stigma with its opposite side, so that cross-pollination is promoted. Crossing is subsequently rendered even more easy, for these anthers turn their pollen-covered surfaces upwards.

VISITORS.—MacLeod observed—in the Pyrenees—a butterfly—Anthocharis belia *Cr.*, var. simplonia *Freyer*, skg.—adapted to the structure of the flower.

236. **S. alba** L. (Hildebrand, Bot. Jahrb., Leipzig, xii, 1881, p. 26; Kirchner, 'Beiträge,' pp. 22–3.)—The crowded golden-yellow flowers exhale an odour like that of vanilla. The claws of the petals are 5 mm. long and at first erect; when the limbs are expanded the diameter of the flower is 15 mm. The stigma, and the anthers of the long stamens, project 2–3 mm. beyond the corolla. Automatic self-pollination does not take place, however, for the anthers turn their dehisced sides outwards, away from the stigma. The two short stamens are 3–4 mm. below the stigma, with their pollen-covered sides facing inwards. Two of the four nectaries are internal to the bases of the long stamens.

VISITORS.—On cultivated plants at Kiel I noticed the honey-bee, skg., and also a hover-fly—Eristalis tenax *L.*, po-dvg.

67. Erucastrum Presl.

The yellowish flowers are homogamous or slightly protogynous, with exposed nectar. Four nectaries.

237. **E. obtusangulum** Reichb. (Kirchner, 'Beiträge,' pp. 22–3.)—The sepals of plants at Zermatt project horizontally, as in the case of Sinapis arvensis, so that the nectar is accessible to insects from the outside. But the flowers are so crowded that it is more easily reached from above. There are four functional nectaries, of which two—according to Velenovský's figure—are broad and flat, and situated on the inner sides of the bases of the two short stamens, projecting between the claws of the petals. The latter are 5 mm. long, upwardly directed, and closely apposed laterally. When the limbs are fully expanded the diameter of the corolla is about 12 mm. Before dehiscence the anthers have a dark red spot at the tip. They all turn the dehisced side inwards, but are remote from the stigma, which is simultaneously mature, and is placed just above the entrance of the flower, so that when the flowers are in the erect position, automatic self-pollination cannot usually take place. The lower ends of the anthers of the long stamens are at the same level as the stigma; those of the two short stamens are somewhat lower.

VISITORS.—MacLeod observed—in the Pyrenees—6 bees, 6 Lepidoptera, a beetle, 5 Syrphidae, one of the Bombyliidae, and a Muscid. ('Pyreneenbl.,' p. 392.)

68. Diplotaxis DC.

The moderately large yellow flowers have a pleasant odour, and are homogamous, with half-concealed nectar. Four nectaries.

238. **D. tenuifolia** DC. (MacLeod, 'Untersuchungen ü. d. Befrucht. einiger phanerog. Pfl. d. belg. Flora,' II; Kirchner, 'Flora v. Stuttgart,' p. 301; Schulz,

'Beiträge,' II, p. 15; Herm. Müller, 'Alpenblumen,' p. 150.)—Only the two smaller of the four nectaries are functional. These are situated on the inner side of the bases of the two short stamens. The two others are much larger, are placed external to the bases of the pairs of long stamens, and face obliquely outwards. The two sepals opposite the functional nectaries are erect, while the two others are horizontal. The short stamens turn the dehisced sides of their anthers inwards; the anthers of the long stamens are directed towards the short ones. Insects probing for nectar must therefore usually effect cross-pollination. Failing insect-visits self-pollination results from contact between the anthers and stigma.

Visitors.—Hermann Müller observed 2 Muscidae, 2 Apidae (Halictus), and a Lepidopterid in the Alps. Schulz noticed numerous flies and Lepidoptera, more rarely Hymenoptera and beetles. MacLeod—in Flanders—saw 2 hover-flies, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 202).

239. D. muralis DC. (Kirchner, 'Beiträge,' pp. 23–4.)—The flower mechanism essentially agrees with that of the last species, but all four nectaries are functional, and the four sepals all oblique. The flowers have a diameter of 16–20 mm. The limbs of the petals are so broad that they somewhat overlap. When the flower opens the anthers are ripe, and the stigma fully mature. The latter is at first either rather lower than the anthers of the four long stamens, or just at the same level. These anthers turn their dehisced sides outwards, but automatic self-pollination is inevitable, for they are coated almost all round with pollen, and quite near the stigma. When the flowers have completely opened the stigma projects beyond the anthers of the long stamens, so that cross-pollination is favoured when insects visit the flowers. The anthers of the two short stamens are turned inwards, and situated about 3 mm. below those of the long ones.

Visitors.—MacLeod observed the following in Flanders.—Apis, a species of Halictus, 4 hover-flies, a Muscid, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 203).

69. Eruca DC.

Large yellowish homogamous flowers, with half-concealed nectar. Four nectaries.

240. E. sativa Lam. (Hildebrand, 'Vergleich. Untersuchungen ü. d. Saftdr. d. Cruciferen'; Kirchner, 'Beiträge,' p. 21.)—The delicate whitish-yellow petals with their dark-brown veins spread out into a cross about 25 mm. in diameter. The flowers are homogamous. The anthers dehisce introrsely, and are placed so close to the stigma that automatic self-pollination is inevitable. Of the four nectaries only the two large flat ones at the inner sides of the short stamens are functional, while the two others—situated outside the bases of the two pairs of long stamens—do not secrete.

70. Vesicaria Lam.

Yellow flowers, with half-concealed nectar.

241. V. arctica R. Br.—Warming observed in Greenland that fruits were set even at a height of 700 m. Nothing is known about the flower mechanism.

242. V. utriculata L.—Briquet ('Études d. biol. flor. d. les Alpes occident.') gives the diameter of the yellow corolla as 15 mm., and states that the claws of

the petals along with the sepals form a tube 1–1½ mm. wide and 15 mm. long. At the bases of the two short stamens there are four nectaries, of which the secretion collects in the bottom of the tube just mentioned. Cross-pollination predominates, for the stigma projects somewhat beyond the anthers of the four long stamens—which are in the entrance of the flower—so that automatic self-pollination is usually impossible. The two outer stamens are sometimes as long as the four inner ones. The flowers examined by Kirchner (Bot. Centralbl., Cassel, lxix, 1897, p. 20, note) were odourless; they exhibited slight protogyny, and their diameter was 15–22 mm.

71. **Alyssum** Tourn.

Flowers rather small, yellow, homogamous to protogynous, with half-concealed nectar. Usually four nectaries. There is sometimes no nectar.

243. **A. calycinum** L. (Kirchner, 'Flora v. Stuttgart,' p. 304; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Knuth, '*Bloemenbiol. Bijdragen.*')—The small flowers—1·5–2 mm. in diameter—are devoid of nectar; they are at first bright yellow, but subsequently colourless. The erect sepals closely ensheath the claws of the petals. The anthers dehisce introrsely, and as those of the short stamens are at the same level as the stigma, while those of the long ones project beyond it, automatic self-pollination is inevitable. Kerner says that there is at first slight protogyny, so that in the early stage insect-visits must effect cross-pollination, but failing these the stamens incline towards the stigma towards the end of anthesis, and autogamy results.

Visitors.—In the Kiel Botanic Garden I have observed Syritta pipiens *L.* skg.; Herm. Müller ('Weit. Beob.,' I, p. 327)—in Thuringia—saw one of the Conopidae—Myopa testacea *L.*—skg.

244. **A. montanum** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' II, p. 15.)—The homogamous yellow flowers are rather small, and smell like honey. There are four functional nectaries, two in the angle at the bases of the short stamens, and two between the long stamens of each pair. The anthers are usually at the same level as the stigma, which matures at the same time. In fine weather the petals and stamens spread out to some extent, when cross-pollination is likely to result from insect-visits. In dull weather and at night the petals and stamens are closely applied to the pistil, so that automatic self-pollination must result. Kerner says that the conspicuousness of the inflorescence is greatly enhanced by growth of the petals after the flowers have opened.

Visitors.—Schulz noticed flies. Hermann Müller observed the following in his garden.—

A. Coleoptera. *Telephoridae*: 1. Dasytes plumbeus *Müll.*, freq. **B. Diptera.** (*a*) *Muscidae*: 2. Sp. of Anthomyia, freq., skg.; 3. Lucilia cornicina *F.*, skg. persistently. (*b*) *Syrphidae*: 4. Eristalis sepulcralis *L.*, in large numbers, skg.; 5. Syritta pipiens *L.*, freq., skg. and po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 6. Halictus nitidiusculus *K.* ♀, freq., skg. and po-cltg.; 7. Nomada ruficornis *L.*, skg.; 8. Prosopis ♂, in large numbers, skg. (*b*) *Sphegidae*: 9. Cerceris rybiensis *L.*, not infrequent, skg.

Friese saw in Hungary the rare species Andrena tscheki *Mor.* (=A. nigrifrons *Sm.*). Ducke records from Trieste, Andrena tscheki *Mor.* ♀, and A. (Biareolina) neglecta *Dours* ♂.

245. **A. alpestre** L. (Kirchner, 'Beiträge,' pp. 25–6.)—The homogamous flowers smell of honey, and those growing on the 'yellow wall' at Zermatt are of a golden-yellow colour. Their diameter is 3–4 mm. The four nectaries are on either side the bases of the two short stamens. The anthers of the four long stamens are at the same level as the stigma—which matures simultaneously—and both project about 1 mm. above the entrance to the flower, in which the anthers of the two short stamens are situated. The anthers dehisce introrsely and remain facing inwards, but they are so far removed from the stigma that automatic self-pollination is not completely assured.

246. **A. saxatile** L.—

VISITORS.—Loew observed the Syrphid Eristalis sepulcralis *L.*, skg., in the Berlin Botanic Garden.

72. **Aubrietia** Adans.

247. **A. Columnae** Guss.—

VISITORS.—Loew saw the honey-bee skg. in the Berlin Botanic Garden.

248. **A. spathulata** DC.—

VISITORS.—As A. Columnae.

73. **Berteroa** DC.

White homogamous flowers with half-concealed nectar. Four nectaries.

249. **B. incana** DC. (Schulz, 'Beiträge,' I, p. 4; Kirchner, 'Flora v. Stuttgart,' p. 304; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 209; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Blütenbiol. Herbstbeob.,' 'Bloemenbiol. Bijdragen.')—There are four nectaries, one internal to either side the base of each short stamen. The anthers of the long stamens project a little beyond the stigma, and turn towards the anthers of the short stamens as soon as the flower opens. The long stamens reach the level of the stigma, but their filaments are bent in such a way as to remove them tolerably far from it. As, however, the anthers of these stamens are usually slightly incurved at the tip, automatic self-pollination is easily possible. The open passage to the secretion above each nectary is narrowed by the tooth-like process of a short stamen, so that when the proboscis of an insect is introduced it must be inserted between a short stamen and the adjacent long one, which explains the rotation of the long stamens at the entrance of the flower.

Warnstorf says that the flowers are protogynous, and that the stigma is already mature in the half-open blossom, the long stamens being at about this stage much shorter than the style, and with unripe anthers. When the petals expand these stamens elongate and project a little beyond the stigma, so that autogamy can readily take place. The pollen-grains are yellow, ellipsoidal, finely tuberculated, about 35 μ long and 15 μ broad.

VISITORS.—On garden plants at Kiel I observed the following skg. hover-flies.—Eristalis arbustorum *L.*, E. nemorum *L.*, Rhingia rostrata *L.*, Syritta pipiens *L.*, and Syrphus ribesii *L.*; salo a butterfly—Vanessa io. *L.* Warnstorf noticed bees at Ruppin; and Alfken saw the bee Halictus brevicornis *Schenck* ♀, skg., at Bremen.

74. Lunaria L.

Large violet homogamous flowers, devoid of odour, and with concealed nectar.

250. **L. annua** L. (=L. biennis *Mnch.*). (Knuth, 'Bloemenbiol. Bijdragen,' and Bot. Centralbl., Cassel, lxx, 1897, pp. 339–40.)—The flower mechanism closely resembles that of Matthiola incana, but the corolla-tube is only 10 mm. long, so that the nectar is accessible to comparatively short-tongued insects. The calyx is deeply cordate at the base, and the sepals are closely apposed, so as to hold the claws of the violet petals together to form a tube. The anthers of the four long stamens project half-way out of the entrance of the flower, turning their closely-juxtaposed pollen-covered sides inwards. Self-pollination may, therefore, take place automatically by the fall of the pollen, or may be effected by insect-visits. The two short stamens arch outwards at their bases, thus leaving room for the nectaries lying internal to them, as well as for the secretion. The anthers of the two short stamens—like those of the long ones—mature simultaneously with the stigma, and turn their dehisced

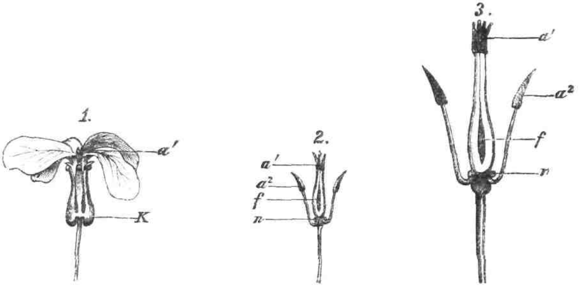

FIG. 31. *Lunaria annua, L.* (from nature). (1) Flower, natural size: *K*, pouch at the base of the calyx; a^1, anthers, half projecting from the entrance of the flower. (2) Stamens and pistil, after removal of sepals and petals: the short stamens diverging, natural size; a^1, anthers of the long stamens; a^2, anther of one of the short stamens; *f*, the lower part of the pistil visible between the filaments of the long stamens which envelope it; *n*, nectary with drop of nectar. (3) As (2), but ×2.

sides towards it. Self-pollination by means of the short stamens is, however, scarcely possible, for the filaments of the long stamens closely surround the pistil, thus protecting the stigma from contact with the anthers of the short ones. When an insect visits more than one flower the pollen of these short stamens is introduced between the filaments of the long ones—which are pressed apart—dusts the stigma, and effects cross-pollination.

The proboscis of an insect probing for nectar gets covered with pollen from the two short stamens, for it has to be thrust between the inner sides of these and the outer sides of the long stamens. Only a proboscis at least 10 mm. long can secure all the nectar, but one of half that length can reach that part of it which ascends to the middle of the corolla-tube.

Small insects collecting or devouring pollen can only obtain it from the anthers of the long stamens, which project somewhat from the flower, and in doing so they may effect self-pollination by shaking down pollen upon the stigma. Failing insect-visits, autogamy results automatically from the fall of pollen.

VISITORS.—In the Garden of the Ober Realschule at Kiel I have observed nectar-skg. butterflies—Vanessa urticae *L.*, and Pieris brassicae *L.* ♂. These regularly fly from flower to flower and thus effect cross-pollination. I have further seen, skg., Anthophora pilipes *F.* ♂, which has a longer proboscis than any other of our spring bees; and also Bombus lapidarius *L.* ♀ and ☿. Several honey-bees made persistent efforts to suck nectar, and as they visited numerous flowers successively I was able to detect the sucking movements, so that they evidently succeeded in reaching the nectar with their proboscis (6 mm. long), and effected cross-pollination in the same way as Lepidoptera. A small pollen-collecting bee—Andrena gwynana *K.* ♀—occasionally effected self-pollination, as did a pollen-devouring hover-fly—Syritta pipiens *L.*

251. **L. rediviva** L.—

VISITORS.—Loew saw the honey-bee sucking the flowers of this species in the Berlin Botanic Garden.

75. **Schievereckia** Andr.

Flowers with half-concealed nectar. Four nectaries.

252. **S. podolica** Andrz. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 175, 339.)—There is a nectary on either side the base of each short stamen. Self-pollination is at first precluded by protogyny. Even after the dehiscence of the anthers it is at first prevented, for the stamens remain at a distance from the stigma. Towards the end of anthesis autogamy takes place, as the stamens bend towards the middle of the flower.

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *F.*, nect-lkg. **B. Diptera.** *Syrphidae*: 2. Eristalis aeneus *Scop.*, po-dvg. **C. Hymenoptera.** *Apidae*: 3. Andrena parvula *K.* ♀, skg. and po-cltg.; 4. Apis mellifica *L.* ☿, skg.; 5. Halictus nitidiusculus *K.* ♀, skg. and po-cltg.

76. **Petrocallis** R. Br.

Rose-coloured homogamous flowers, with half-concealed nectar. Four nectaries.

253. **P. pyrenaica** R. Br. (Schulz, 'Beiträge,' II, p. 16.)—There is a richly secreting nectary on either side the base of each short stamen. At the beginning of anthesis the anthers of these stamens are at the same level as the stigma—which is already mature—but the filaments curve outwards at their bases, so that there is no contact. The filaments of the long stamens are parallel for half their length, and then bend outwards. Their anthers are curved downwards, and lie almost immediately above those of the short stamens. They cannot easily effect automatic self-pollination.

VISITORS.—Schulz—in the Tyrol—saw numerous flies and Lepidoptera, which in many cases would effect self- as well as cross-pollination.

77. Erophila DC.

Small white flowers, homogamous to slightly protogynous, with half-concealed nectar. Four nectaries.

254. E. verna E. Meyer (=Draba verna *L.*). (Herm. Müller, 'Fertilisation,' p. 105, 'Weit. Beob.,' I, p. 327; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.,' p. 70; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Kirchner, 'Flora v. Stuttgart,' p. 305; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 28.)—The four small green nectaries are situated on either side the base of each short stamen. The pollen-covered sides of the four long stamens lie close to the stigma—which matures simultaneously—and as they discharge a cloud of pollen when even slightly shaken automatic self-pollination is inevitable. Hildebrand's experiments prove this to be effective. The anthers of the short stamens are lower than the stigma, and serve for cross-pollination. While Müller describes the flowers as homogamous, Kerner says that they are protogynous at the beginning of the first day of anthesis, though later on that day the anthers dehisce and automatic self-pollination is effected by bending of the stamens towards the middle of the flower. Kerner also states that the petals increase greatly in size during anthesis. The flowers open about nine in the morning, and close about six o'clock in the evening.

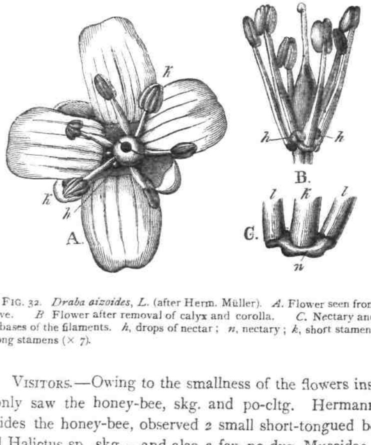

FIG. 32. *Draba aizoides, L.* (after Herm. Müller). *A.* Flower seen from above. *B* Flower after removal of calyx and corolla. *C.* Nectary and the bases of the filaments. *h*, drops of nectar; *n*, nectary; *k*, short stamen; *l*, long stamens (× 7).

Jordan distinguishes between short-fruited and long-fruited forms or varieties of Erophila. The former have the structure just described; in the latter the stigma projects beyond the anthers, and it therefore frequently happens that no fruits are set.

VISITORS.—Owing to the smallness of the flowers insect-visits are rare. At Kiel I only saw the honey-bee, skg. and po-cltg. Hermann Müller—in Westphalia—besides the honey-bee, observed 2 small short-tongued bees—Andrena parvula *K.* ♀, and Halictus sp., skg.—and also a few po-dvg. Muscidae—Anthomyia sp., Hylemyia cinerella *Mg.*, and Sarcophaga carnaria *L.*

Alfken observed the following at Bremen.—

A. Hymenoptera. *Apidae*: 1. Andrena parvula *K.* ♀, po-cltg. and skg., ♂ skg.; 2. Apis mellifica *L.* ☿, po-cltg. and skg.; 3. Bombus terrester *L.* ♀, skg.; 4. Halictus calceatus *Scop.* ♀, skg. and po-cltg.; 5. H. morio *F.* ♀, skg. and po-cltg.; 6. Halictus nitidiusculus *K.* ♀, skg. and po-cltg. **B. Diptera.** *Muscidae*: 7. Musca domestica *L.* ♂, skg.

MacLeod saw 2 Muscids in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 210), and Burkill ('Fertlsn. of spring fls.') noticed—on the Yorkshire coast—a minute short-tongued Dipterid. skg. nectar. In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire, p. 17) a beetle and 2 flies have been recorded.

78. Draba L.

Small white or yellow flowers, homogamous or protogynous, with half-concealed to completely-concealed nectar.

255. **D. aizoides** L. (Hildebrand, 'Vergleich. Untersuch. ü. d. Saftdr. d. Cruciferen,' p. 13; Herm. Müller, 'Alpenblumen,' pp. 145-6; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II.)—The flowers are at first golden yellow, subsequently whitish. In the first (female) stage the stigma projects beyond the still unripe stamens. The anthers only dehisce when these have grown so far that the long ones reach the level of the stigma towards which they may then incline, effecting automatic self-pollination. In sunny weather, however, the stamens spread out, rendering the nectar visible, and cross-pollination is effected by insect visitors.

Visitors.—Hermann Müller observed flies—7 Muscidae and 6 Syrphidae—10 Lepidoptera, and a beetle in the Alps.

256. **D. Zahlbruckneri** Host. (Kirchner, 'Beiträge,' p. 26.)—Self-pollination is possible in a late stage of anthesis of the golden yellow protogynous flowers, as a result of the fall of pollen. On either side of each short stamen there is a small functional nectary.

257. **D. Wahlenbergii** Hartm. (Herm. Müller, 'Alpenblumen,' p. 146; Warming, 'Biol. Optegn. om Grönl. Pl.')—This species is homogamous. Failing insect-visits, self-pollination regularly takes place.

In Greenland it produces ripe fruits (Abromeit, 'Bot. Ergeb. d. Drygalski's Grönlands-Exped.,' pp. 25-6).

258. **D. Thomasii** Koch.—

Visitors.—Hermann Müller—in the Alps—observed chiefly flies—3 Muscidae and a Syrphid.

259. **D. frigida** Sauter.—Flowers homogamous and capable of self-pollination.

Visitors.—Hermann Müller observed a Muscid ('Alpenblumen,' p. 147).

260. **D. incana** L.—Warming says that in Greenland this species is homogamous and capable of automatic self-pollination. According to the same authority this is also true in the same country for.—

261. **D. nivalis** Liljebl., 262. **D. corymbosa** R. Br., 263. **D. arctica** J. Vahl, and 264. **D. Hirta** L., with its variety *Hartm.*, while its variety leiocarpa *Lindbl.* is not so easily automatically self-pollinated. Abromeit (op. cit., pp. 25-6) states that D. arctica and D. hirta produce ripe fruits in Greenland, where D. nivalis with its small white flowers ascends to a height of 3,000 feet above sea-level (op. cit., pp. 24-5).

265. **D. aurea** M. Vahl.—Warming says that this species differs from the preceding in having the nectar more deeply concealed. The long claws of the petals are closely apposed to form a tube, so that only insects with a long proboscis can reach the nectar. In the homogamous flowers automatic self-pollination can only be effected by the long stamens, while the short ones serve for cross-pollination.

266. **D. alpina** L.—Lindman says that this species is homogamous—on the Dovrefjeld—and capable of automatic self-pollination.

According to Ekstam, the protogynous-homogamous flowers in Nova Zemlia agree in structure with those of Scandinavia and Greenland. The same botanist has observed plants in Spitzbergen bearing flowers and fruits during the height of summer ('Blütenbiol. Beob. a. Spitzbergen,' p. 20). The flowers were homogamous, 5–7 mm. in diameter, faintly fragrant, and with yellow petals.

VISITORS.—In Spitzbergen, Ekstam observed that the flowers were visited by a number of small Diptera.

267. **D. crassifolia** L.—Warming says that this species is homogamous and autogamous in the Arctic regions.

79. Kernera Med.

Small white homogamous flowers, with half-concealed nectar. Four nectaries.

268. **K. saxatilis** Reichb. (= Cochlearia saxatilis *Lam.*). (Herm. Müller, 'Alpenblumen,' p. 147.)—The flowers are homogamous. There is a green fleshy nodule secreting nectar on either side the base of each short stamen. The petals are at first small and erect, but subsequently expand. The anthers of the four long stamens are close to those of the two short ones: all six dehisce introrsely, and are so placed that an insect sucking nectar must touch them with one side, and the stigma with the other side, thus favouring cross-pollination. In dull weather the flowers remain half closed, when automatic self-pollination takes place. The pistil turns to purple-brown in the older flowers.

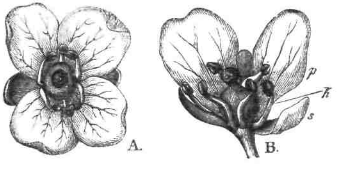

FIG. 33. *Kernera saxatilis, Reichb.* (after Herm. Müller). *A.* Flower seen from above. *B.* Flower after removal of two petals: seen from the side; *k*, short stamen. (× 7.)

VISITORS.—Hermann Müller—in the Alps—observed chiefly flies—5 Muscidae, an Empid, and 3 Syrphidae—also several bees—Andrena, and beetles—Meligethes.

80. Cochlearia L.

White, odorous, homogamous flowers, either with half-concealed nectar, or else nectarless.

269. **C. Armoracia.** (Herm. Müller, 'Weit. Beob.,' II, p. 198; Kirchner, 'Flora v. Stuttgart,' p. 305; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Kerner, 'Nat.

Hist. Pl.,' Eng. Ed. 1, II; Knuth, 'Bloemenbiol. Bijdragen.')—There are muriform nectaries at the bases of the stamens in the fragrant flowers, but the secretion is very scanty. All the anthers dehisce introrsely; those of the long stamens are at the same level as the stigma, which matures simultaneously. This being in the entrance to the flower, cross-pollination is likely to be effected by insect visitors. Self-pollination may also easily occur, though Kerner says that it is almost or entirely ineffective. According to Warnstorf, the flowers are protogynous, and the stigmatic papillae mature before anthesis. The same authority states that all the stamens project beyond the stigma. The pollen-grains are yellowish, ellipsoidal, tuberculated, on an average 37–43 μ long and 15–19 μ broad.

VISITORS.—Hermann Müller (H. M.) and myself (Kn.) have observed the following.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes sp. in immense numbers (Kn., H. M.). (*b*) *Telephoridae*: 2. Malachius bipustulatus *L.*, dvg. the anthers (H. M.). **B. Diptera.** (*a*) *Bibionidae*: 3. Bibio hortulanus *L.*, searching for nectar (?) (H. M.). (*b*) *Empidae*: 4. Empis punctata *F.*, skg. (H. M.). (*c*) *Muscidae*: 5. Scatophaga merdaria *F.*, skg. (H. M.); 6. Sepsis sp. (Kn.). (*d*) *Syrphidae*: 7. Eristalis sp., skg. and po-dvg. (Kn.); 8. Syritta pipiens *L.*, ditto (H. M., Kn.); 9. Syrphus balteatus *Deg.* ditto (Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 10. Andrena albicans *Müll.* ♀, ditto (H. M.); 11. Halictus levis *K.* ♀, skg. (H. M.); 12. H. zonulus *Sm.* ♀, skg. (H. M.). (*b*) *Ichneumonidae*: 13. Several sp., searching for nectar (H. M.).

270. **C. officinalis** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 29, 149.)—The flowers are 8–10 mm. in diameter. Those I examined appeared to have no nectaries. Burkill ('Fertlsn. of spring fls.'), on the other hand, says that on the Yorkshire coast there are four well-marked nectaries at the base of the flower. The anthers of the four long stamens are at the same level as the stigma—which matures simultaneously—and at first somewhat turned away from it. The anthers of the short stamens dehisce rather later, and in early anthesis are lower than the stigma, though subsequently they reach its level. Automatic self-pollination is therefore quite possible. Either cross-pollination or self-pollination may be effected by insect visitors while collecting pollen, or boring in the base of the flower for sap.

Andersson and Hesselman state ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 34–40) that the diverse varieties included by Gelert in this strongly polymorphous species—as β. *groenlandica* (L.) Gel., γ. *oblongifolia* (DC.) Gel., and δ. *arctica* (Schlecht.) Gel.—bloom in Spitzbergen from early spring to autumn, fruits being set from the end of July till autumn. The plant flowers abundantly on Beeren Island in mid-July. According to Ekstam the flowers of C. arctica *Schlecht.* have a diameter of 3–4 mm. and are apparently protogynous-homogamous. Some of them are female.

VISITORS.—I have observed various flies—Syrphidae and Muscidae—and beetles—Meligethes. Loew saw the honey-bee in the Berlin Botanic Garden. Burkill ('Fertlsn. of spring fls.') noticed the following on the Yorkshire coast.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes picipes *Sturm*, skg. **B. Diptera.** *Muscidae*: 2. Coelopa sp., skg.; 3. Hylemyia sp., skg.; 4. Drosophila graminum *Fall.*, skg.; 5. Scatophaga stercoraria *L.*, skg. and po-dvg.; 6. another small Muscid. **C. Hymenoptera.** *Ichneumonidae*: 7. Ichneumon sp., skg.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 16) a Muscid and Meligethes have been recorded.

In Spitzbergen Ekstam only saw a medium-sized Dipterid.

271. C. arctica Schlecht.—Ekstam says that in Nova Zemlia self-pollination is brought about by the closing of the flowers.

272. C. danica L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' 'Bl. u. Insekt. a. Helgoland.')—The diameter of the flower is only 4–5 mm. I could find no nectaries. The anthers of the long stamens dehisce first, but from the beginning they are directed towards the stigma, projecting a little beyond it. Those of the short stamens dehisce soon afterwards, and then all the anthers incline towards the middle of the flower, thus effecting automatic self-pollination, provided that autogamy or allogamy has not previously resulted from insect-visits. Autogamy is effective in any case.

Visitors.—In Schleswig-Holstein I observed ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 149) flies—Syrphidae and Muscidae—and also a nect.-lkg. ant. On Helgoland (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 38) I also saw the following: *Syrphidae*: 1. Eristalis sp.; 2. Syritta pipiens *L.* Besides these I noticed—on June 5, 1897—minute Muscidae persistently working in the bases of the flowers, and obviously getting sap; but I did not succeed in repeating the observation.

273. C. groenlandica L.—Warming states that there are two non-functional nectaries. The anthers do not touch the stigma—which matures simultaneously—but autogamy takes place, apparently by closing of the flower at night or during unfavourable weather. It must be effective, for numerous fruits are set. Kerner says that autogamy is brought about as in Schievereckia. (See p. 107.)

81. Eutrema R. Br.

274. E. Edwardsii R. Br.—Ekstam states that the odourless flowers are homogamous in Nova Zemlia. Their diameter in Arctic Siberia is usually 5 mm., according to Kjellmann. Self-pollination is possible.

Andersson and Hesselman state ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 34) that this arctic species ceases flowering in Spitzbergen in the middle of July, but it is not known whether ripe fruits are produced. Vanhöffen found a fruiting plant in Greenland on August 20, 1892 (see Abromeit, 'Bot. Ergeb. d. Drygalski's Grönlands-Exped.,' p. 27).

82. Camelina Crantz

Yellow homogamous flowers with half-concealed nectar. Four nectaries.

275. C. sativa Crantz (= C. microcarpa *Andrz.*). (Kirchner, 'Flora v. Stuttgart,' p. 306; Warnstorf, Verh. bot. Ver., Berlin, xxxvii, 1895, and xxxviii, 1896; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 29–30, 'Bloemenbiol. Bijdragen.')—There are four nectaries, two outside the base of each short stamen. The diameter of the corolla is only 4 mm. The anthers of the long stamens are at the same level as and very close to the stigma, so that they can effect self-pollination. Those of the short stamens are lower than and curved outwards away from the stigma. They serve for cross-

pollination. Warnstorf describes the pollen-grains as pale yellow, ovoid or ellipsoidal, very finely papillated, about 37·5 μ in length and 27·5 μ in breadth.

VISITORS.—On cultivated plants at Kiel I only observed Meligethes.

83. Subularia L.

Minute, homogamous, often cleistogamous flowers. I could not see any nectaries.

276. S. aquatica. (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.'; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 30; Hiltner, 'Untersuch. ü. d. Gatt. Subularia'; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.')—This plant, which flowers under the water, is cleistogamous. In the land variety I investigated the pollen-covered anthers were very close to the stigma. Hiltner says that in the submerged—and consequently cleistogamous—flowers there are large stigmatic papillae, which receive the pollen directly. More seeds are set than in the chasmogamous variety living on river-banks.

VISITORS.—In Dumfriesshire a fly was recorded (Scott-Elliott, 'Flora of Dumfriesshire,' p. 17).

84. Thlaspi Dill.

White or lilac, homogamous and protogynous flowers, with half-concealed nectar. Four nectaries.

277. T. arvense L. (Herm. Müller, 'Weit. Beob.,' II, pp. 198–9; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 211; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 335; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 30.)—The small white flowers have a green fleshy nectary on either side the base of each short stamen. The anthers of the four long stamens are at the same level or a little higher than the stigma, which matures simultaneously. They turn their pollen-covered surfaces towards the stigma, and are so near it that automatic self-pollination is inevitable. The anthers of the two short stamens are somewhat lower than the stigma, to which they also turn their dehisced sides. They are further from the stigma, and serve for cross-pollination by insect agency.

Warnstorf says that all the stamens project beyond the stigma, and that their introrsely dehiscing anthers are inclined over it, making autogamy inevitable. The pollen-grains are yellowish-white, ellipsoidal, tuberculated, about 25–30 μ long and 20–23 μ broad.

According to Kerner there is slight protogyny, but automatic self-pollination takes place later by contact of the anthers with the stigma.—Hieronymus observed cleistogamous flowers.

VISITORS.—Hermann Müller observed the following in Westphalia.—**A. Diptera.** *Muscidae*: 1. Anthomyia sp. ♀; 2. Pollenia rudis *F.* **B. Hymenoptera.** *Apidae*: 3. Andrena parvula *K.* ♀, skg. and po-cltg.; 4. Apis mellifica *L.* ☿, skg.

278. T. perfoliatum L. (Kirchner, 'Flora v. Stuttgart,' p. 307.)—The flowers are even smaller than those of the last species, and therefore more inconspicuous; especially as the petals bend outwards but little. The conspicuousness of the inflorescence is, however, enhanced by the fact that the petals do not fall off as soon as fertilization is effected. The flower mechanism agrees with that of T. arvense.

In dull weather the flowers are closed or only slightly open, while even in sunshine they expand so little that their opening is only about 1 mm. in diameter.

279. T. montanum L. (Kirchner, 'Beiträge,' pp. 26–7; the description refers to plants from the Swabian Alps.)—The white flowers are of considerable size, with confluent nectaries. The anthers of the four long stamens are at the same level as the stigma—which matures simultaneously—and turn their pollen-covered surfaces towards it. The anthers of the short stamens, which are at a somewhat lower level, dothis also.

280. T. alpinum Crantz. (Kirchner, 'Beiträge,' p. 27; the description refers to specimens from the Riffelberg, near Zermatt.)—The nectaries are confluent, as in the last species, forming a studlike projection at the base of the flower, into which the stamens are inserted. The flowers are white, and when fully expanded their diameter is 7 mm. Although they are homogamous, automatic self-pollination is prevented by projection of the stigma about 1 mm. beyond the anthers of the long stamens. All six anthers turn their pollen-covered surfaces inwards: those of the long stamens project a little from the entrance of the flower, while those of the short ones are about 1 mm. within it.

VISITORS.—Pollination can only be effected by insects, but regarding these we have as yet no knowledge.

281. T. alliaceum L.—Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 333) says that the flowers are protogynous, but that at a later stage automatic self-pollination takes place by contact of the dehiscing anthers with the stigma.

282. T. alpestre L.—The homogamous flowers are white in colour, and their anthers are first yellow, then purple-red, and finally black.

VISITORS.—Hermann Müller observed 9 flies and 2 Lepidoptera ('Alpenblumen,' p. 147). Buddeberg saw 17 bees, 7 flies, 2 saw-flies, a solitary wasp, and a beetle (Justs bot. Jahresber., Leipzig, xvi (1888), 1890, p. 564).

283. T. rotundifolium Gaud. (Schulz, 'Beiträge.')—The bright violet flowers are conspicuous among the white dolomitic gravel, on which the plant grows in the south Tyrol, often in patches a square metre in size. Nectar is secreted abundantly at the bases of the short stamens, and concealed at a depth of 3–4 mm. The anthers of the long stamens are usually at the same level as the stigma, and ultimately turn completely round towards those of the short stamens. They do not touch the stigma—which matures simultaneously—nor can the anthers of the short stamens do so, for they are at a lower level. Automatic self-pollination does not therefore take place.

VISITORS.—Schulz observed butterflies—Pieris, Vanessa cardui—and flies.

284. T. corymbosum Gay. (Kirchner, 'Beiträge,' pp. 27–8.)—On the Riffelberg, near Zermatt, the flowers are bright lilac to violet in colour, fragrant, and aggregated into relatively large inflorescences. The diameter of the individual flowers varies from 6 to 10 mm. There is slight protogyny; at the beginning of anthesis the anthers are unripe, while the stigma—which is situated in the entrance of the flower—is already mature. By the time the flowers are fully expanded the anthers of the four long stamens have opened, and those of the two short ones do so soon afterwards.

All of them dehisce introrsely, and remain in their original position; those of the long stamens project a little from the entrance of the flower, while those of the short stamens—together with the stigma—are in it. Automatic self-pollination is possible, though the anthers are remote from the stigma.

285. **T. praecox** Wulf.—

VISITORS.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena convexiuscula *K.*; 2. A. deceptoria *Schmiedekn.*; 3. A. tscheki *Mor.* (*b*) *Tenthredinidae*: 4. Athalia rosae *L.*, var. liberta *Klug*.

85. Teesdalia R. Br.

Small, white, bilaterally symmetrical flowers, with half-concealed nectar. Four nectaries.

286. **T. nudicaulis** R. Br. (Herm. Müller, 'Fertilisation,' pp. 106–8, 'Weit. Beob.,' II, pp. 199–200; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 20, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 231.)—Hermann Müller says that during anthesis the flowers are aggregated to form a flat surface, and the outer petals are larger than the others, as in the Umbelliferae. In Teesdalia, however, as the flowers successively fade the axis of the inflorescence lengthens, and the flat surface is drawn out into a raceme, each flower becoming marginal in its turn. Hence all the flowers have the outer side of the corolla enlarged, and not only—as in the Umbelliferae and Compositae—those which are originally at the edge.

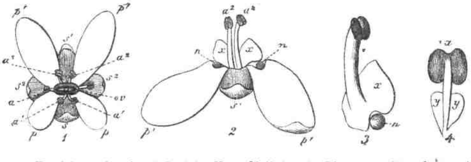

FIG. 34. *Teesdalia nudicaulis*, *R. Br.* (after Herm. Müller). (1) Flower seen from above. (2) Anterior half of a flower. (3) One of the long stamens with a nectary, seen from outside. (4) One of the two short stamens, seen from outside. *s*, inner sepal; s^1, outer sepal; s^2, lateral sepal; *p*, inner petal; p^1, outer petal; *a*, short stamens; a^1, inner long stamens; a^2, outer long stamens; *x*, *y*, petaloid appendages of the filaments; *n*, nectary; *ov*, ovary.

The white-tipped sepals enhance conspicuousness, but this is chiefly attained by the white petals, supplemented by petaloid appendages of the filaments. The appendages of the four inner stamens closely surround the compressed ovary. Each of these possesses a small pouch immediately above the middle of the base of the adjacent petal, which is also pouched. Between the two, is a small green fleshy nectary, which is functional, and appears to belong to the torus.

The anthers of the four long stamens project somewhat beyond the stigma, while those of the two short ones are at the same level. All six make a quarter-turn when the flower opens; each long one turning towards the adjacent short one, while each of these is directed towards the outside of the inflorescence. The anthers now dehisce, and the stigma simultaneously matures. Insects probing towards either

of the two outer nectaries, touch two of the adjacent anthers with their head or proboscis, while those trying to get at one of the two inner drops of nectar, only come into contact with one anther. In either case they touch the stigma with the other side of their head or proboscis. They may therefore effect either cross- or self-pollination. Failing insect-visits, the long stamens effect automatic self-pollination.

VISITORS.—Hermann Müller observed the following at Lippstadt.—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Cassida nebulosa *L.*; 2. Aphthona nemorum *L.*, skg.: 3. Chaetocnema concinna *Marsh.*, skg. (*b*) *Curculionidae*: 4. Ceutorhynchidius pumilio *Gyll.*, skg. (*c*) *Elateridae*: 5. Limonius parvulus *Pz.* (*d*) *Hydrophilidae*: 6. Paracercyon analis *Pk.* **B. Diptera.** (*a*) *Bibionidae*: 7. Bibio laniger *Mg.*, skg. (*b*) *Empidae*: 8. Empis sp., skg. (*c*) *Muscidae*: 9. Onesia floralis *R.-D.*, po-dvg.; 10. Sarcophaga carnaria *L.* ♀; 11. Themyra putris *L.*, skg. (*d*) *Syrphidae*: 12. Ascia podagrica *F.*, po-dvg.; 13. Melithreptus sp., po-dvg. **C. Hymenoptera.** *Apidae*: 14. Halictus flavipes *F.* ♀, skg. and po-cltg.; 15. H. lucidulus *Schenck* ♀, ditto; 16. H. morio *F.* ♀, ditto; 17. H. nitidiusculus *K.* ♀, ditto; 18. H. sexstrigatus *Schenck* ♀, ditto; 19. H. smeathmanellus *K.* ♀, ditto; 20. Sphecodes ephippus *L.*, skg.

In the island of Föhr I saw Muscidae; while MacLeod in Flanders noticed 2 Dipterids (Bot. Jaarb. Dodonea, Ghent, vi, 1894, p. 211).

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 17) small flies have been recorded.

86. Iberis L.

White to lilac homogamous flowers, with half-concealed nectar.

287. I. amara L. (=I. Forestieri *Jord.*) and **288. I. umbellata** L.—The outer petals of the marginal flowers are twice as large as the inner ones (Kerner).

VISITORS of I. amara (= I. Forestieri *Jord.*).—MacLeod noticed a Muscid in the Pyrenees. Alfken observed the following *Apidae*, skg., at Bremen.—

1. Andrena albicans *Müll.* ♂; 2. A. albicrus *K.* ♂; 3. A. praecox *Scop.* ♂; 4. Bombus lapidarius *L.* ♀; 5. B. lucorum *L.* ♀; 6. B. terrester *L.* ♀; 7. Osmia rufa *L.* ♂.

289. I. pinnata L.—Hildebrand states that this species is almost self-sterile (Ber. d. bot. Ges., Berlin, xiv, 1896).

290. I. saxatilis L.—According to Briquet ('Études d. biol. flor. d. les Alpes occident.') the sepals are spreading and the corolla white and zygomorphous. The diameter of the corollas of the outer flowers of each inflorescence is about 5 mm., and the inner flowers are only about half as large. The stigma is beneath the introrse anthers of the four long stamens, but as these turn outwards, while those of the two short ones dehisce laterally, insect agency is necessary for pollination, although the flowers are homogamous. After fertilization the filaments and style assume a dark violet colour (according to Kirchner).

VISITORS.—Cross- and self-pollination are brought about by flies, wasps, bees, and Lepidoptera.

87. Biscutella L.

Yellow homogamous flowers, with half-concealed nectar. Four nectaries, of which, however, only two are functional.

291. B. laevigata L. (Herm. Müller, 'Alpenblumen,' pp. 148–9.)—The flowers are aggregated into conspicuous inflorescences. Outside the base of each short stamen there is a nectary, the secretion of which collects in the cavity of the sepal immediately below it. There is a non-secreting nodule outside the base of each pair of long stamens. Each petal possesses a basal lobe each side, the one on the side next the short stamen being considerably larger than the other, and thus serving as a nectar-cover for the functional nectaries, leaving free but a small passage to the secretion. The reduction of the other lobes of the petals is correlated with the vestigial condition of the remaining nectaries.

The anthers are so placed that every insect approaching the nectar must on three sides touch a dehisced anther, and on the fourth come into contact with the simultaneously mature stigma. An insect passing from flower to flower will therefore continually effect cross-pollination. Failing insect-visits, the anthers and stigma are

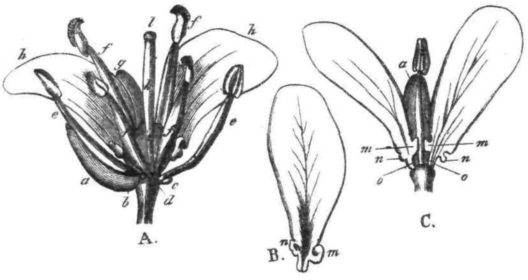

FIG. 35. *Biscutella laevigata*, *L.* (after Herm. Müller). *A.* Flower after removal of two sepals and two petals: seen from the side. *B.* Petal seen from the inner side. *C.* A short stamen with the two adjacent petals (× 7). *a*, one of the lower sepals with a cavity (*b*) in its base, which serves as a nectar reservoir; *c*, functional nectary; *d*, vestigial nectary; *e*, the two short stamens, which dehisce introrsely; *f*, the four long stamens, which dehisce towards the short ones; *g*, one of the upper sepals; *h*, petals; *i*, ovary; *k*, style; *l*, stigma; *m*, larger lobe of a petal; *n*, smaller lobe of a petal; *o*, entrance to the nectar.

brought into contact by the closing of the flower, so that automatic self-pollination ensues.

VISITORS.—Herm. Müller observed 23 flies, 5 Hymenoptera, 6 Lepidoptera, and Meligethes in the Alps. Loew noticed one of the Pyralidae, skg., in Switzerland ('Beiträge,' p. 56).

88. Lepidium L.

Small white or yellow flowers, homogamous or protogynous, with half-concealed nectar. Four or six nectaries. The corolla is sometimes absent.

292. L. Draba L. (Kirchner, 'Flora v. Stuttgart,' pp. 308–9; Kerner, 'Nat. Hist. Pl.' Eng. Ed. 1, I, p. 432.)—The small white flowers are not individually conspicuous, but many of them are aggregated together. In favourable weather the flower opens so widely at the beginning of anthesis that its diameter is 6–7 mm.,

and the six small green nectaries—situated outside and between the bases of the six stamens—are readily accessible even to short-tongued insects. The anthers project beyond the stigma and are turned towards it, but automatic self-pollination is at first prevented by the filaments curving outwards. Insects visiting the flower at this stage will touch the stigma and the pollen with different sides of their body, and may easily effect cross-pollination. At a later stage the parts of the flower are somewhat closer together, reducing the diameter to 4–5 mm. At the same time the anthers approach the stigma so closely that automatic self-pollination must result. According to Kerner, the flower is slightly protogynous. The same authority states that the anthers of the long stamens conceal themselves behind the petals during the first stage of anthesis, so that they cannot be touched by insect visitors.

VISITORS.—Redtenbacher noticed—in Austria—a Nitidulid, Meligethes lepidii *Mill.*, and an Oedemerid, Nacerdes viridipes, *Schmidt*. Schletterer observed the following bees at Pola.—1. Halictus interruptus *Pz.*; 2. H. malachurus *K.*; and 3. H. minutus *K.*

293. **L. sativum** L. (Herm. Müller, 'Fertilisation,' pp. 110–11, 'Weit. Beob.,' II, p. 204; Kirchner, 'Flora v. Stuttgart,' p. 310; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 508.)—The white flowers are inconspicuous, but being strongly odorous are readily discovered and much visited by insects. The four nectaries are situated in the intervals between the long and short stamens. The anthers dehisce introrsely, but in sunny weather they curve so far outwards that automatic self-pollination cannot take place, though cross-pollination may be effected by insect visitors. In dull weather, or failing insect-visits, autogamy obtains as a last result by closure of the flowers. Kerner states that the species is slightly protogynous.

VISITORS. — Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Andrenus pimpinellae *F.* (H. M.). (*b*) *Telephoridae*: 2. Anthocomus fasciatus *L.* (H. M.); 3. Dasytes plumbeus *Müll. F.* (H. M.); 4. Malachius bipustulatus *F.*, gnawing anthers and petals (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 5. Argyromoeba sinuata *Fall.* (H. M.). (*b*) *Muscidae*: 6. Siphona cristata *F.* (H. M.). (*c*) *Syrphidae*: 7. Ascia podagrica *F.*, very freq., skg. and po-dvg. (H. M.); 8. Eristalis arbustorum *L.*, skg. and po-dvg. (H. M.); 9. E. nemorum *L.*, ditto (H. M.); 10. E. sepulcralis *L.*, ditto (H. M.); 11. Helophilus floreus *L.*, ditto (H. M.); 12. Melithreptus taeniatus *Mg.*, ditto (H. M.); 13. Pipiza chalybeata *Mg.*, ditto (H. M.); 14. Syritta pipiens *L.*, freq., ditto (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 15. Andrena carbonaria *L. F.* ♂ (H. M.); 16. A. parvula *K.* ♀, skg. (H. M.); 17. Halictus lucidulus *Schenck* ♀, skg. (H. M.); 18. H. nitidiusculus *K.* ♀, skg. (H. M.); 19. Prosopis bipunctata *F.* ♂, skg. (Budd.); 20. P. communis *Nyl.* ♂ and ♀, ditto (H. M.); 21. P. hyalinata *Sm.*, ♂ and ♀, very freq., skg. and po-cltg. (H. M.). (*b*) *Chrysididae*: 22. Hedychrum nobile *Scop. F.* ♂ (H. M.). (*c*) *Ichneumonidae*: 23. An undetermined sp., occasional (H. M.). (*d*) *Sphegidae*: 24. Cerceris rybiensis *L.*, very freq. (H. M.); 25. Pemphredon unicolor *F.* (H. M.); 26. Oxybelus bellus *Dahlb.*, freq. (H. M.); 27. O. uniglumis *L.*, very freq. (H. M.). **D. Lepidoptera**: 28. Sesia tipuliformis *Cl.*, skg. repeatedly (H. M.).

294. **L. ruderale** L. (Kirchner, 'Flora v. Stuttgart,' p. 310; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 30; Warnstorf, Verh. bot. Ges., Berlin, xxxviii, 1896.)—The small greenish-white flowers only occasionally possess petals. Of the original six stamens only the two short ones are retained, a small nectary taking the place

of each of the four long ones. The stamens are at the same level as the stigma, and mature simultaneously. They regularly effect automatic self-pollination, which is effective, according to Comes ('Stud. s. impoll. i. alc. piante'). Warnstorf says that the anthers of the two stamens are pressed against the mature stigma by two sepals when the flower opens.

295. L. campestre L.—According to Kirchner ('Beiträge,' pp. 28–9), the very small white flowers are only 2 mm. in diameter when expanded. On either side of the base of each short stamen there is a small green nectary (Velenovský figures 6 nectaries). The six anthers—which mature simultaneously—turn their dehisced sides towards the stigma. The sepals when they wither close together in such a way as to press all the stamens against the stigma, thus effecting automatic self-pollination, which is probably indispensable. Kerner says that this species is slightly protogynous.

296. L. graminifolium L.—

Visitors.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Prosopis genalis *Thoms* (=P. confusa *Först.*). (*b*) *Ichneumonidae*: 2. Amblyteles litigiosus *Wesm.* (*c*) *Sphegidae*: 3. Pemphredon unicolor *F.*

89. Hutchinsia R. Br.

Small, white, homogamous or protogynous flowers, with half-concealed nectar. Four nectaries.

297. H. alpina R. Br. (Herm. Müller, 'Alpenblumen,' p. 150; Schulz, 'Beiträge,' II, p. 17.)—Hermann Müller describes the flowers as protogynous, with persistent stigmas. Only some of the plants he examined—at Albula Hospice—were capable of automatic self-pollination: in these the four long stamens reached the stigma. A. Schulz describes the flowers—for the South Tyrol—as homogamous or nearly so, and automatically self-pollinated by contact of the anthers of the long stamens with the stigma. Kerner states that autogamy takes place as in Schievereckia (see p. 107).

90. Capsella Vent.

Small, white, homogamous flowers with half-concealed nectar. Four nectaries.

298. C. Bursa-pastoris Moench. (Herm. Müller, 'Fertilisation,' p. 110, 'Weit. Beob.,' II, p. 204; Kirchner, 'Flora v. Stuttgart,' p. 311; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 31, 149; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The four nectaries are at the sides of the short stamens. All the anthers remain turned towards the stigma, those of the four long stamens being at the same level, and so near it that automatic self-pollination—which is effective—regularly takes place. Insect visitors may effect either cross- or self-pollination.

Breitenbach observed relatively large female flowers in addition to the hermaphrodite ones (Justs bot. Jahresber., Leipzig, xii (1884), 1886, p. 676).

Willis (Proc. Phil. Soc., Cambridge, 1893) also observed gynomonoecism and gynodioecism in England. Burkill's investigations ('Fertlsn. of spring fls.') prove that cold produces gynodioecism and gynomonoecism in this species. Plants that

flowered on the Yorkshire coast soon after the rigorous weather of January and February, 1895, possessed only reduced stamens, and it was not till the beginning of April that hermaphrodite flowers appeared. After the mild winter of 1896 the first plants were female, but hermaphrodite ones were seen towards the end of March. The female flowers had an average diameter of 3 mm., so that in Yorkshire they do not exceed the hermaphrodite ones in size, though Breitenbach (Kosmos, Lwów, iii, 1878, p. 206) observed larger female flowers in Germany.

It was also noticed by Warnstorf that the stamens are frequently reduced in the first flowers that appear at Ruppin: later in the season only hermaphrodite flowers are found with anthers at the same level as the stigma, making self-pollination inevitable. Anna Bateson ('Effect of cross-fertlsn. on inconspicuous fls.') determined by culture experiments that the plants produced by crossing are not noticeably larger than those resulting from self-pollination, but they are somewhat heavier, the relative weights being as 100 : 88.

Visitors.—Hermann Müller in Westphalia (H. M.), Buddeberg (Budd.) in Nassau, and myself (Kn.), have observed the following.—

A. Coleoptera. *Mordellidae*: 1. Anaspis rufilabris *Gyll.* (H. M.). **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia, skg. (H. M.). (*b*) *Syrphidae*: 3. Ascia podagrica *F.*, skg. (H. M.); 4. Chrysotoxum bicinctum *L.*, po-dvg. (Budd.); 5. Eristalis nemorum *L.*, skg. and po-dvg. (H. M.); 6. E. sp., ditto (Kn.); 7. Melithreptus pictus *Mg.*, skg. and po-dvg. (H. M.); 8. M. scriptus *L.*, ditto (H. M.); 9. M. taeniatus *Mg.*, ditto (H. M.); 10. Syritta pipiens *L.*, ditto (H. M., Kn. in Helgoland); 11. Syrphus balteatus *Deg.*, ditto (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 12. Prosopis pictipes *Nyl.* ♂, skg. (Budd.); 13. P. bipunctata *F.* ♂, skg. (Budd.). (*b*) *Sphegidae*: 14. Sapyga clavicornis *L.*, skg. (Budd.). **D. Lepidoptera.** *Tineidae*: 15. Adela violella *Tr.*, skg. (H. M.). **E. Thysanoptera**: 16. Thrips, freq. (H. M.).

Schmiedeknecht noticed the bee Andrena distinguenda *Schenck* in Thuringia, and Alfken saw A. flavipes *Pz.* ♀, skg., at Bremen. Verhoeff observed the following in Baltrum.—

Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Cynomyia mortuorum *L.* (*b*) *Syrphidae*: 3. Syritta pipiens, *L.*, po-dvg. and skg.

Von Dalla Torre noticed the bee Andrena rosae *Pz.* ♂ in the Tyrol, where it was also seen by Schletterer. The latter further observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena parvula *K.*; 2. Eucera longicornis *L.*; 3. Halictus malachurus *K.* (*b*) *Tenthredinidae*: 4. Athalia spinarum *F.*; 5. A. rosae *L.*, var. liberta *Klug*.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 18) Apis, a short-tongued bee, 3 hover-flies, and 4 Muscidae have been recorded.

MacLeod—in Flanders—observed Apis, 9 short-tongued Hymenoptera, hover-flies, a Muscid, a beetle, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 212), and—in the Pyrenees—a Muscid and a Lepidopterid ('Pyreneenbl.,' p. 396).

299. C. pauciflora K. — Kirchner (Jahresber. Ver. Nat., Stuttgart, v, 1893, p. 100) states that this species does not secrete nectar in its natural habitat (under overhanging rocks in the South Tyrol). Individual plants cultivated under very favourable circumstances possessed very small dark-green functional nectaries on either side the base of each short stamen.

91. Aethionema R. Br.

300. A. saxatile R. Br.—According to Briquet ('Études d. biol. flor. d. les Alpes occident.') the upright sepals are edged with white, while the red-veined white or bright rose-red petals spread out above. The stigma is at first beneath the anthers, but subsequently the style elongates. Kirchner adds that the flowers are slightly protogynous, that the diameter of the upper part of the corolla is 3–4 mm., and that automatic self-pollination is regularly effected by the anthers of the four long stamens.

Visitors.—These are flies and small beetles, which chiefly effect self- but occasionally cross-pollination.

301. A. grandiflorum Boiss. et Hohen.—Hildebrand says that this species is self-sterile (Ber. D. bot. Ges., Berlin, xiv, 1896, p. 324).

92. Coronopus Haller.

Small, white, homogamous to protogynous flowers, with half-concealed nectar. Four nectaries.

302. C. Ruellii All. (Kirchner, 'Flora v. Stuttgart,' p. 312; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 213; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' 'Bl. u. Insekt. a. Helgoland'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The small white flowers are arranged in dense helicoid inflorescences in the forks of the branches, especially in the middle of the plant, which is closely applied to the ground. The diameter of the flower is only 4 mm. On either side each short stamen—and therefore apposed to a petal—there is a relatively large green nectary, which secretes so abundantly that the base of the ovary glistens all round. When the flower opens all the anthers are still unripe, and at the same level as the stigma, which would appear to be already mature. When the petals expand the stamens curve away from the stigma, on the side facing which they dehisce almost simultaneously. Cross-pollination may therefore result from insect-visits. Failing these, however, automatic self-pollination is ensured later on, by the petals inclining together and bringing the anthers into direct contact with the stigma. Warnstorf says that two of the sepals bend inwards during anthesis, pressing the long stamens against the stigma so that autogamy takes place. The pollen-grains are whitish, ellipsoidal, closely tuberculated, 25–30 μ long and 15–18 μ broad.

Visitors.—In Helgoland I observed 2 small *Muscidae*, i. e. Coelopa frigida *Fall.* and Fucellia fucorum *Fall.*, both skg.

93. Isatis L.

Small, yellow, homogamous flowers, with half-concealed nectar. Six nectaries.

303. I. tinctoria L. (Kirchner, 'Flora v. Stuttgart,' p. 313; Knuth, 'Bloemenbiol. Bijdragen.')—In spite of the smallness of the individual flowers the inflorescences are very conspicuous owing to their size. Kirchner says that the six nectaries are situated between the six stamens, which curve outwards so as to be a long way

from the stigma, and turn their dehisced sides upwards. Insect visitors therefore chiefly effect cross-pollination.

VISITORS.—On garden plants at Kiel I observed the following.—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.*, skg. **B. Hymenoptera.** *Apidae*: 2. Andrena parvula *K.* ♀, skg.; 3. Apis mellifica *L.*, skg. **C. Coleoptera.** 4. Meligethes.

Loew noticed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Telephoridae*: 1. Cantharis rusticus *Fall.* **B. Diptera.** (*a*) *Bibionidae*: 2. Bibio hortulanus *L.*, skg. (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*, skg.

94. **Myagrum** Tourn.

Small, yellow, homogamous flowers, with half-concealed nectar. Two functional and two vestigial nectaries.

304. **M. perfoliatum** L.—Kirchner ('Flora v. Stuttgart,' p. 313) says that the flower possesses a well-developed nectary internal to the base of each short stamen, while the nectaries belonging to the longer stamens are only represented by narrow green stripes. Automatic self-pollination is possible and effective.

VISITORS.—Schletterer observed the following *Apidae* at Pola.—

1. Andrena carbonaria *L.*; 2. A. deceptoria *Schmiedekn.*; 3. A. flavipes *Pz.*; 4. A. lucens *Imh.*; 5. A. morio *Brull.*; 6. A. parvula *K.*; 7. Halictus levigatus *K.*; 8. H. quadricinctus *F.*; 9. H. scabiosae *Rossi*.

95. **Neslia** Desv.

Small, yellow, homogamous flowers, with half-concealed nectar. Two nectaries.

305. **N. paniculata** Desv.—Kirchner ('Flora v. Stuttgart,' p. 314) states that the two nectaries are but feebly represented by small swellings, upon which the short stamens are seated. All the anthers turn their dehisced sides towards the stigma. Automatic self-pollination is easily possible, for, according to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), the anthers project a little beyond the stigma. The same authority (op. cit., xxxvii, 1895) describes the pollen-grains as pale yellow, ellipsoidal, finely papillated, about 31 μ long and 25 μ broad.

96. **Bunias** L.

Yellow, homogamous flowers, with half-concealed nectar. Two nectaries.

306. **B. orientalis** L.—The golden-yellow odorous flowers, which are aggregated into large inflorescences, possess but two nectaries, according to Kirchner ('Flora v. Stuttgart,' pp. 314–15). These are placed on the inner sides of the short stamens, and their secretion is scanty. The diameter of the flowers is 11 mm. The anthers of the long stamens project beyond the stigma and turn their dehisced sides upwards. Those of the two short stamens are at about the same level as the stigma, but curve outwards away from it, and remain perpendicular. They dehisce somewhat later than the anthers of the long stamens, and their dehisced sides are directed inwards. It follows that either cross- or self-pollination may result from insect-visits. Automatic self-pollination takes place by the fall of pollen from

the anthers of the long stamens upon the stigma, and according to Comes ('Stud. s. impoll. i. alc. piante') it is effective. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes the flower as protogynous. The pollen-grains are pale yellow, ellipsoidal, with reticulated ridges, about 44 μ long and 25 μ broad.

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Bibionidae*: 1. Bibio hortulanus *L.* ♀ and ♂, skg. (*b*) *Syrphidae*: 2. Ceria conopsoides *L.*, skg.; 3. Eristalis arbustorum *L.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Andrena propinqua *Schenck* ♀, skg. and po-cltg.; 5. Prosopis communis *Nyl.* ♂, skg. (*b*) *Tenthredinidae*: 6. Cephus sp. ♀.

307. B. Erucago L.—Comes says that this species is self-fertile.

VISITORS.—Schletterer observed the following bees at Pola.—

1. Andrena flavipes *Pz.*; 2. A. nana *K.*; 3. Halictus fasciatellus *Schenck*; 4. H. morbillosus *Kirchb.*; 5. H. morio *F.*

97. Cakile Tourn.

Moderately large homogamous flowers, bright violet to almost white, with concealed nectar. Four nectaries.

308. C. maritima Scop. (MacLeod, Bot. Jaarb. Dodonaea, Ghent, i, 1889; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 31–2, 149–50, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 231, 'Bl. u. Insekt. a. Helgoland.')—The fragrant flowers possess four nectaries: a larger triangular one between and outside the two long stamens of each pair, and a small bilobed one internal to each short stamen. The closely apposed sepals hold the claws of the petals together so as to form a vertical tube 4–5 mm. long, in which nectar collects, often so abundantly as to half fill it. The anthers of the long stamens project beyond the corolla, so that automatic self-pollination may take place by the fall of pollen upon the stigma, which is placed in the entrance of the flower and matures simultaneously. The anthers of the short stamens remain enclosed in the flower, and reach the level of the stigma.

Insects are as likely to effect cross- as self-pollination. When probing for nectar—as in the case of all Cruciferae—they thrust their head or proboscis between the stigma and anthers so as to dust only one side of it, provided they work round the flower, and do not repeat the process. If the other side of the head or proboscis had previously been dusted in another flower, the stigma will be cross-pollinated. If an insect thrusts its head into the flower first on one side and then on the other, self-pollination will result. After several flowers have been visited by an insect, both sides of its head will be dusted, and every fresh visit will effect cross-pollination.

VISITORS.—I have observed the following at Kiel and in the North Frisian Islands.—

A. Coleoptera. 1. Meligethes. **B. Diptera.** (*a*) *Muscidae*: 2. Aricia albolineata *Fall.*; 3. Musca domestica *L.*; 4. Onesia sepulcralis *Mg.*; 5. Scatophaga merdaria *F.*; 6. S. stercoraria *L.*; all po-dvg. (*b*) *Syrphidae*: 7. Eristalis arbustorum *L.*; 8. E. pertinax *Scop.*; 9. E. sp.; 10. E. tenax *L.*; 11. Platycheirus podagratus *Zett.*; 12. Rhingia campestris *Mg.*; 13. Syrphus arcuatus *Fall.*; 14. S. umbellatarum *F.*; 15. Tropidia milesiformis *Fall.*, all skg. and po-dvg. **C. Hymenoptera.** (*a*) *Apidae*:

16. Apis mellifica *L.*; 17. Bombus lapidarius *L.*; 18. Halictus calceatus *Scop.* **D. Lepidoptera.** (*a*) *Noctuidae*: 19. Plusia gamma *L.* (*b*) *Rhopalocera*: 20. Epinephele janira *L.*; 21. Hipparchia hyperanthus *L.*; 22. Pieris napi *L.*; 23. P. rapae *L.*; 24. Vanessa urticae *L.* (*c*) *Zygaenidae*: 25. Zygaena filipendulae *L.*; all skg.

On the dunes of Helgoland—where there are no bees—I noticed the following on July 9, 1895.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella septempunctata *L.* (*b*) *Oedemeridae*: 2. Nacerdes melanura *L.* (*c*) *Telephoridae*: 3. Psilothrix cyaneus *Ol.* (= Dolichosoma nobilis *Rossi*). **B. Diptera.** (*a*) *Syrphidae*: 4. Syrphus arcuatus *Fall.* ♀ and ♂; 5. S. pyrastri *L.* ♀ and ♂; 6. Eristalis tenax *L.*; 7. E. sp. (*b*) *Muscidae*: 8. Calliphora vomitoria *L.* ♂. **C. Lepidoptera.** *Noctuidae*: 9. Plusia gamma *L.* All the insects very freq., the beetles po-dvg., the flies and moth skg. nectar.

Alfken and Leege recorded the following from Juist.—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 1. Bombus lapidarius ☿ and ♂, very freq., skg.; 2. B. lucorum *L.* ☿ and ♂, very freq., skg.; 3. B. ruderatus *F.* ♂, infrequent, skg.; 4. B. terrester *L.* ☿, skg.; 5. Psithyrus rupestris *F.* ♂, freq., skg.; 6. P. vestalis *Fourcr.* ♂, freq., skg. (*b*) *Chrysididae*: 7. Chrysis ignita *L.* (*c*) *Scoliidae*: 8. Tiphia femorata *F.* (*d*) *Pompilidae*: 9. Pompilus chalybeatus *Schjödte*; 10. P. plumbeus *F.* **C. Lepidoptera.** (*a*) *Pieridae*: 11. Pieris brassicae *L.*; 12. P. napi *L.* (*b*) *Satyridae*: 13. Hipparchia semele *L.*, freq.

Verhoeff observed the following in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes aeneus *L.*, freq. (*b*) *Scarabaeidae*: 2. Phyllopertha horticola *L.* **B. Diptera.** (*a*) *Bombyliidae*: 3. Phthiria canescens *Löw.* (*b*) *Syrphidae*: 4. Eristalis arbustorum *L.*, skg.; 5. E. intricarius *L.*, skg. and po-dvg.; 6. E. tenax *L.*, one ♂, skg. and po-dvg.

MacLeod saw a small nocturnal moth at Blankenberge.

In Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 19) a Muscid and Meligethes have been recorded.

98. Rapistrum Boerh.

Yellow, homogamous flowers, with half-concealed nectar. Four nectaries.

309. R. rugosum Bergt. (Kirchner, 'Beiträge,' pp. 24–5; Hildebrand, 'Vergleich. Untersuch. ü. d. Saftdr. d. Cruciferen,' p. 25.)—Of the four nectaries (figured by Velenovský), two are actively secreting swellings on the inner side of the bases of the short stamens: their nectar collects in pouches of the sepals. The two other nectaries are smaller and papilliform. They lie outside and between the long stamens of each pair, and secrete but little. The diameter of the flower is 10 mm.: the erect sepals are 5 mm. long, and hold the claws of the petals—which are of equal length—in a vertical position. The anthers of the four long stamens are 1–1½ mm. above the entrance of the flower, and the stigma—which matures simultaneously—is at the same level. Although these anthers turn their dehisced sides outwards they get covered with pollen all round, and are so near the stigma that automatic self-pollination no doubt sometimes occurs. The anthers of the two short stamens only reach the entrance of the flower, where they spread out to some distance from the pistil, thus serving for cross-pollination (Kirchner). The species is almost self-sterile according to Hildebrand (Ber. D. bot. Ges., Berlin, 1896).

99. Crambe Tourn.

Moderately large, white, slightly protogynous flowers, with half-concealed nectar. Four nectaries.

310. **C. maritima** L. (Knuth, Bot. Centralbl., Cassel, xliv, 1890, pp. 305–8.)—The flowers—of which the diameter is 12 mm.—possess an odour of honey, and are aggregated into large crowded inflorescences. The reddish-white sepals project outwards and upwards, supporting the expanded petals, the white limbs of which are almost horizontal. The claws of the petals are at first yellowish-green, subsequently becoming bright violet-red. The filaments and style pass through the same changes of colour, but the anthers and stigma are yellow throughout anthesis. The interior of a young mature flower is therefore yellowish-green, while that of an older one is of a discoloured violet. At the base of each pair of long stamens there is a large rounded green nectary, to which the drop of nectar remains clinging. On the inner side of each short curved stamen there is also a much smaller nectary of the same colour. The filaments of the long stamens are forked, and their anthers are borne on the branches adjacent to the short stamens. Owing to the forking of the filaments the heads of nectar-seeking insects have to be thrust into the flower at defined spots, contact with anthers and stigma being thus secured.

The stigma matures in the bud—while the anthers are still unripe—and at the beginning of anthesis is situated in the entrance of the flower. The filaments elongate very soon after, thus bringing up the anthers from beneath the stigma. Dehiscence then takes place. The anthers of the long stamens are now somewhat higher than the stigma, while those of the short ones are at the same level.

Visitors.—Insects while probing for nectar—provided they are large enough to touch anthers and stigma simultaneously—will regularly effect crossing if they thrust their heads into the flower only once. The honey-bee behaved in this way. Other insects of about the same size, e. g. some of the hover-flies (Eristalis tenax *L.*, Syrphus ribesii *L.*) did not always do so, and therefore sometimes effected self-pollination. Another hover-fly (Syritta pipiens *L.*) when sucking nectar was too slender to touch both stamens and carpels, being therefore of no use to the plant. The same is true for two Muscidae (Borborus sp., and Phora pulicaria *Fall.*). I also found in the flowers numerous small po-dvg. beetles (Meligethes brassicae *Scop.*, more rarely M. viridescens *F.*), as well as their larvae. The adults in most cases effect self-pollination, but may also occasionally bring about cross-pollination. The larvae of Meligethes are found not only in the fully developed flowers, but also in the buds, where they are very abundant. They destroy the stamens and pistil, so that many flowers are infertile. The question arises whether the beetles and their larvae are to be regarded only as enemies of the plant. I am inclined to maintain the negative, for these small insects are apparently among the most important, if indeed they are not the chief pollinators of the species; and if they and their larvae are present in but small numbers, many flowers would remain unfertilized, though it is true that many others would escape destruction. On the other hand, should the beetles be too numerous the damage outweighs the benefit. The beetles, however, will then suffer proportionately, for only a small number will be able to develop, and this again will react unfavourably upon pollination.

A certain intermediate number of beetles will therefore be of use to the plant, and this mean will always be maintained for the mutual benefit of plant and insect (cf. vol. I, p. 102).

In Dumfriesshire 2 Muscidae and also Meligethes have been observed (Scott-Elliot, 'Flora of Dumfriesshire,' p. 19).

311. **C. tatarica** Wulf. — According to Kerner's researches artificial self-pollination is ineffective.

312. **C. pinnatifida** R. Br.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden, all skg.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. Syritta pipiens *L.*; 3. Syrphus ribesii *L.* **B. Hymenoptera.** *Apidae*: 4. Apis mellifica *L.*

313. **C. grandiflora** DC.—

VISITORS.—Loew observed a hover-fly (Melithreptus scriptus *L.*, skg.) in the Berlin Botanic Garden.

100. Raphanus Tourn.

Whitish, homogamous flowers, with half-concealed nectar. Four nectaries.

314. **R. Raphanistrum L.** (Herm. Müller, 'Fertilisation,' p. 113, 'Weit. Beob.,' II, p. 205; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 208; Kirchner, 'Flora v. Stuttgart,' p. 302; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 32, 140, 'Bl. u. Insekt. a. d. Ins. Rügen'; Warnstorf, Verh. bot. Ver., Berlin, xxxvii, 1895.)—The nectaries are situated as in Sinapis arvensis, but owing to the erect position of the sepals their secretion is not visible and easily accessible from without. The petals are either white with violet veins, or bright yellow with dark yellow veins. All the anthers turn their dehisced sides towards the stigma, beyond which the long stamens project, while those of the short ones are at the same level. Automatic self-pollination therefore appears to be even more favoured than in Sinapis, but it is ineffective. Warnstorf describes the pollen-grains as being pale yellow in colour, ellipsoidal, very finely reticulated and tuberculated, about 37·5 μ long and 31 μ broad.

VISITORS.—Hermann Müller (H. M.) in Westphalia, myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes brassicae *Scop.* (Kn.). **B. Diptera.** *Syrphidae*: 2. Melanostoma gracilis *Mg.*, skg. (Kn.); 3. Rhingia rostrata *L.*, freq., skg. and po-dvg. (H. M.); 4. Syritta pipiens *L.*, po-dvg. (H. M., Kn.); 5. Syrphus ribesii *L.*, po-dvg. (H. M.); 6. S. sp. (Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 7. Apis mellifica *L.* ☿, skg. and po-cltg. (H. M., Kn.); 8. Bombus lapidarius *L.*, skg. (Kn.); 9. B. muscorum *F.* ♀, skg. (H. M.); 10. B. pratorum *L.*, skg. (Kn.); 11. B. variabilis *Schmied.* ♀, skg. (H. M.); 12. Halictus flavipes *F.* ♀, skg. (H. M.); 13. H. smeathmanellus *K.* ♀, skg. (H. M.). (*b*) *Tenthredinidae*: 14. Cephus pygmaeus *Pz.* (H. M.). **D. Lepidoptera.** *Rhopalocera*: 15. Coenonympha pamphilus *L.* (H. M.); 16. Rhodocera rhamni *L.* (Kn.); 17. Lycaena sp. (Kn.); 18. Pieris napi *L.* (Kn.), and 19. P. rapae *L.* (Kn.); all skg.

Alfken noticed the bee Halictus nitidiusculus *K.* ♀ at Bremen.

On the island of Rügen I also observed the following, all skg.—

A. Diptera. *Syrphidae*: 1. Volucella bombylans *L.* **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿. **C. Lepidoptera.** *Rhopalocera*: 3. Pieris sp.; 4. Vanessa urticae *L.*

Schletterer saw the small green bee Halictus morio *F.* at Pola.

In Dumfriesshire, Apis, a humble-bee, Muscids, and Meligethes have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 19).

315. **R. sativus** L.[1]—Kirchner ('Flora v. Stuttgart,' pp. 302-3) has described the structure of the flowers from garden specimens. The petals are white or lilac with darker veins. The diameter of the expanded flower is about 20 mm. There is a large cushion-shaped nectary internal to the base of each short stamen, and a slender peg-like one outside the base of each pair of long stamens. The two outer sepals possess dilatations at their bases for reception of the nectar. The stamens do not undergo rotation, but bend horizontally outwards away from the stigma. The anthers of the four long ones are at the same level as the stigma; those of the two short ones—which curve more markedly outwards—are 2-3 mm. below it. When the flower fades the anthers of the long stamens come into contact with the stigma so that, failing insect-visits automatic self-pollination is effected, which results in normal fruits being set, though only about half of the ovules become seeds. Insect visitors chiefly bring about cross-pollination.

Visitors.—Kirchner observed bees (Apis, species of Bombus), hover-flies, butterflies (Pieris), and beetles (Meligethes). Schletterer gives the following *Apidae* for Pola in the Tyrol.—

1. Andrena carbonaria *L.*; 2. A. deceptoria *Schmiedekn.*; 3. A. flavipes *Pz.*; 4. A. gwynana *K.*; 5. A. nana *K.*; 6. A. thoracica *F.*; 7. Eucera clypeata *Er.*; 8. E. longicornis *L.*; 9. Halictus calceatus *Scop.*; 10. H. malachurus *K.*; 11. Podalirius acervorum *L.*; 12. P. nigrocinctus *Lep.*; 13. P. retusus *L.*, var. meridionalis *Pér.*; 14. Xylocopa violacea *L.*

Andrena gwynana *K.* was also observed in the Tyrol by von Dalla Torre. MacLeod noticed 3 flies and 2 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 209).

101. Lobularia Desd.

316. **L. maritima** Desd.—Hildebrand states that this species is self-sterile (Ber. D. bot. Ges., Berlin, xiv, 1896).

317. **L. nummularia** Stend.—According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 339), this species is protogynous, but towards the end of anthesis autogamy is brought about by the stamens moving towards the middle of the flower, so that the pollen of the long ones reaches the stigma.

102. Clypeola L.

318. **Clypeola Messanensis.**—As No. 317 (cf. loc. cit.).

103. Sobolewskia Bieb.

319. **S. clavata** Frenzl.—Hildebrand (Ber. D. bot. Ges., Berlin, xiv, 1896) says that this species is self-fertile.

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[1] R. sativus and R. Raphanistrum are one species, according to Carrière (André, Belg. Hortic., Liège, xix, 1869, p. 151), and Hoffmann (Bot. Ztg., Leipzig, xxx, 1872; xxxi, 1873; and xlii, 1884).

104. Succowia Medic.

320. S. balearica.—As No. 319.

105. Pugionium Gaertn.

321. P. dolabratum Maxim.—Batalin (Acta horti Petr., St. Peterburg, x, 1889) describes this species as being protandrous.

X. ORDER *CAPPARIDEAE* JUSS.

Some of the species belonging to this order are pollinated by humming-birds. Details will be given elsewhere, when dealing with the extra-European flora.

106. Capparis L.; 107. Cleome Cl.; and 108. Polanisia Rafin.

According to Delpino ('Sugli app. d. fecondaz. n. piante autocarp.'), species of the above three genera are cleistogamous.

XI. ORDER *RESEDACEAE* DC.

109. Reseda L.

Flowers whitish or yellow, homogamous or feebly protandrous, with half-concealed to completely concealed nectar. The petals are split into radiating clavate threads. The torus broadens out at the back into an erect, four-sided disk, the velvety anterior surface of which serves as a nectar-guide, while its posterior smooth surface secretes and conceals the nectar. The expanded claws of the posterior and middle petals protect the nectar from rain and useless visitors (flies). They closely adjoin the posterior side of the disk, and embrace its upper and lateral margins with their forwardly directed lobes. Wilson compares the nectary to a pot of which the lid must be opened by nectar-seeking insects, and short-tongued bees (Prosopis) are better adapted for this than long-tongued ones. The flower is open even in the bud, and the beginning of anthesis is marked by the first secretion of nectar. The ovary projects from the middle of the flower, and serves as the most convenient alighting-place for insects. It follows that these will regularly effect cross-pollination when they have previously visited another flower of the same species (cf. Fig. 36).

322. R. luteola L. (Herm. Müller, 'Fertilisation,' p. 116, 'Weit. Beob.,' II, p. 205; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 214–15; Kirchner, 'Flora v. Stuttgart,' p. 316.)—The inconspicuous bright yellow flowers—open in the bud—are aggregated into moderately conspicuous inflorescences. They quickly wither. The stamens are symmetrically arranged around the pistil, and the three stigmas project a little beyond them. As there is no movement of the stamens during anthesis, automatic self-pollination easily takes place. Beyer states that the stamens dehisce in centrifugal order, unlike those of the other species.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Coleoptera. *Anthribidae*: 1. Urodon conformis *Suffr.* (Budd.); 2. U. rufipes *Oliv.* (Budd.). **B. Hymenoptera.** 3. *Apidae*: Andrena nigroaenea *K.* ♀, in large numbers, skg. (H. M., Thuringia); 4. Apis mellifica *L.* ☿, skg. and po-cltg. (H. M.); 5. Prosopis bipunctata *F.* ♀ (Budd.); 6. P. communis *Nyl.* ♀ and ♂, very freq. (H. M.); 7. P. hyalinata *Sm.* ♂ and ♀, freq., skg. and po-cltg. (H. M.).

323. R. lutea L. (Herm. Müller, 'Fertilisation,' p. 116, 'Weit. Beob.,' II, p. 205; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 213; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Kirchner, 'Flora v. Stuttgart,' p. 315; Schulz, 'Beiträge,' I, p. 4.)—The odourless flowers are bright greenish-yellow, and either homogamous (Kirchner) or slightly protandrous (Schulz). The stamens are at first curved over the pistil. When the secretion of nectar begins some of the anthers dehisce, and their filaments bend up towards the disk. Kirchner says that the stigmatic papillae mature at this stage, but Schulz asserts that they do not do so till all but the innermost anthers have shed their pollen. Failing insect-visits, automatic self-pollination takes place, for the anthers dehisce above the stigma. Autogamy, however, has little or no result (Darwin, Focke). Besides hermaphrodite flowers, Schulz observed here and there andromonoecious ones with undeveloped stigmas. Warnstorf describes the pollen-grains as pale yellowish in colour, ellipsoidal, finely tuberculated, about 44 μ long and 19 μ broad.

Visitors.—Hermann Müller observed the following in Thuringia.—

A. Coleoptera. (*a*) *Anthribidae*: 1. Urodon rufipes *Oliv.*, vainly searching for nectar. (*b*) *Curculionidae*: 2. Baris abrotani *Germ.*, do. (*c*) *Mordellidae*: 3. Anaspis rufilabris *Gyll.* **B. Diptera.** *Muscidae*: 4. Ulidia erythrophthalma *Mg.*, do. **C. Hymenoptera.** (*a*) *Apidae*: 5. Apis mellifica *L.* ☿, skg. and po-cltg.; 6. Halictus sp. ♀, skg.; 7. Prosopis pictipes *Nyl.* ♀, skg.; 8. Pr. signata *Pz.* ♀ and ♂, very freq., skg. (*b*) *Formicidae*: 9. Lasius niger *L.* ☿, do. (*c*) *Ichneumonidae*: 10. Undetermined sp., do. (*d*) *Sphegidae*: 11. Cerceris arenaria *L.*, skg.; 12. C. labiata *F.*, freq., skg.; 13. C. rybiensis *L.*, very freq., skg.; 14. Crabro (Entomognathus) brevis *L.* ♀ and ♂, skg.; 15. Diodontus tristis *L.* ♀, occasional. (*e*) *Vespidae*: 16. Odynerus parietum *L.* ♂, skg.

Loew noticed Prosopis sp. in Steiermark ('Beiträge,' p. 51). The following bees were seen by von Dalla Torre in the Tyrol:—1. Halictus quadricinctus *Fbr.* ♀; 2. H. sexnotatus *K.* ♀. MacLeod observed 7 short-tongued Hymenoptera, a Lepidopterid, 2 Syrphids, and a Muscid, in the Pyrenees ('Pyreneenbl.,' p. 396). Smith records Prosopis bipunctata *F.* (=P. signata *Pz.*) for England.

The following were observed by Schletterer at Pola in the Tyrol.—

Hymenoptera. (*a*) *Apidae*: 1. Anthidium diadema *Ltr.*; 2. A. oblongatum *Ltr.*; 3. Andrena albopunctata *Rossi*; 4. A. convexiuscula *K.*; 5. A. convexiuscula *K.* v. fuscata *K.*; 6. A. flessae *Pz.*; 7. A. labialis *K.*; 8. A. morio *Brull.*; 9. A. parvula *K.*; 10. A. thoracica *F.*; 11. Ceratina cucurbitina *Rossi*; 12. Colletes lacunatus *Dours*; 13. C. niveofasciatus *Dours*; 14. Eucera longicornis *L.*; 15. Halictus calceatus *Scop.*; 16. H. interruptus *Pz.*; 17. H. quadricinctus *F.*; 18. H. sexnotatus *K.*; 19. Nomada nobilis *H. Sch.*; 20. Nomia diversipes *Latr.*; 21. Prosopis clypearis *Schenck.* (*b*) *Ichneumonidae*: 22. Pristomerus vulnerator *Pz.* (*c*) *Pompilidae*: 23. Pseudagenia albifrons *Dalm.*; 24. Salius notatus *Lep.* (*d*) *Sphegidae*: 25. Cerceris arenaria *L.*; 26. C. emarginata *Pz.*; 27. C. quadrifasciata *Pz.*; 28. C. specularis *Costa*; 29. Crabro clypeatus *L.* (*e*) *Tenthredinidae*: 30. Allantus fasciatus *Scop.* (*f*) *Vespidae*: 31. Eumenes pomiformis *Pz.*; 32. Odynerus parietum *L.*; 33. Polistes gallica *L.*

324. R. odorata L. (Herm. Müller, 'Fertilisation,' pp. 114–16, 'Weit. Beob.,' II, p. 205; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 231.)—The *flower mechanism* agrees with that of the last species. The yellowish-white, odorous, homogamous flowers attract numerous small bees, which collect pollen or suck nectar, and effect pollination. Failing insect-visits, automatic self-pollination takes place, and this is effective.

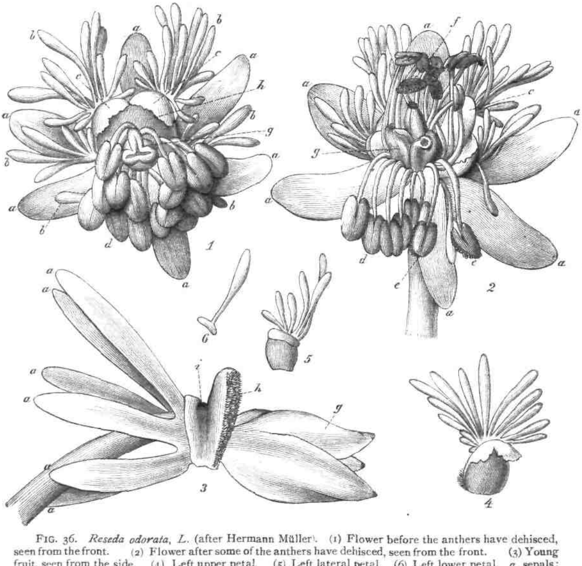

FIG. 36. *Reseda odorata*, *L.* (after Hermann Müller). (1) Flower before the anthers have dehisced, seen from the front. (2) Flower after some of the anthers have dehisced, seen from the front. (3) Young fruit, seen from the side. (4) Left upper petal. (5) Left lateral petal. (6) Left lower petal. *a*, sepals; *b*, petals; *c*, expanded claws of the upper and lateral petals, which embrace the shield-shaped swelling (*h*) of the receptacle; *d*, undehisced stamens bent downwards; *e*, dehiscing stamen raising itself; *f*, dehisced and erect stamen; *g*, pistil; *h*, shield-shaped projection of the receptacle; *i*, nectary with nectar.

VISITORS.—Herman Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, observed the following.—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.*, po-dvg. (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena nigroaenea *K.* ♀, po-cltg. (H. M.); 3. Apis mellifica *L.* ☿, freq., skg. and po-cltg. (H. M., Kn.); 4. Halictus smeathmanellus *K.* ♀, po-cltg. (H. M.); 5. H. zonulus *Sm.* ♀, po-cltg. (H. M.); 6. Prosopis annularis *Sm.* ♀ (=P. panzeri *Först*, according to Dalla Torre) (H. M.), 7. P. bipunctata *F.* ♀ and ♂, freq. (H. M.), 8. P. communis *Nyl.* ♀ and ♂, very freq. (H. M.), 9. P. hyalinata *F.* ♀ and ♂ (H. M.), and 10. P. pictipes *Nyl.* (H. M.); all po-cltg. and skg. (*b*) *Sphegidae*: 11. Cerceris rybiensis *L.* ♀ and ♂, skg. and po-dvg. (H. M.). **C. Lepidoptera.** 12. Pieris sp. (Kn.). **D. Thysanoptera.** 13. Thrips, very freq. (H. M.).

Loew noticed Halictus rubicundus *Chr.* ♂, skg., in Mecklenburg ('Beiträge,' p. 41), and the following (op. cit., p. 33) in Silesia:—**A. Diptera.** *Syrphidae*: 1. Syrphus balteatus *Deg.*, skg. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg.

Schenck observed 3 bees in Nassau:—1. Anthidium oblongatum *Ltr.*; 2. A. punctatum *Ltr.*; 3. A. strigatum *Ltr.*

Alfken saw the following at Bozen.—

A. Hymenoptera. *Apidae*: 1. Coelioxys rufocaudata *Sm.* ♀ and ♂, not infrequent, skg.; 2. Halictus flavipes *F.* ♀, freq., skg. and po-cltg.; 3. Megachile pacifica *Pz.* ♀, freq. **B. Coleoptera.** (*a*) *Buprestidae*: 4. Acmaeodera flavo-fasciata *Pill.* (*b*) *Cerambycidae*: 5. Clytus massiliensis *L.*; 6. C. ornatus *Hbst.*

Friese records the following *Apidae* for Baden (B.), Alsace (A.), Mecklenburg (M.), Nassau (N.), and Hungary (H.).

1. Prosopis bipunctata *F.* (B., A., M.); 2. P. confusa *Nyl.* (M.); 3. P. dilatata *K.* (H.), not infrequent; 4. P. nigrita *F.* (M., H.); 5. Stelis signata *Ltr.* (N., according to Schenck).

325. R. glauca L.—The white flowers—which were investigated by MacLeod in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 397–8)—are aggregated into conspicuous inflorescences. The nectary is a semicircular white disk on the posterior side of the ovary. Nectar is secreted by its central part, which is partly covered by the claw-lobes of the two upper petals, so that the secretion is only visible from in front. The flowers therefore belong to the class **EC.**

When the flower opens the four stigmas are mature, and may therefore be cross-pollinated by insects. The anthers of the upper stamens dehisce subsequently, and those of the lower ones still later. Automatic self-pollination may result from the fall of pollen out of the upper anthers on to the stigma.

VISITORS.—MacLeod observed **Hymenoptera**—6 species of Andrena, 2 of Halictus, and one of Polistes—and **Diptera**—*Syrphidae* and *Muscidae*.

XII. ORDER *CISTINEAE* DUNAL.

White or brightly coloured pollen flowers, generally large, homogamous or slightly protogynous. They open only in the sunshine, and usually remain open but for a short time (a few hours). The absence of nectar is compensated for by the production of large quantities of pollen. When cross-pollination is not effected, autogamy is brought about by closure of the flowers. There are often cleistogamous flowers, as, for example—according to M. Kuhn—in species of Lechea (Bot. Ztg., Leip., xxv, 1867, p. 67).

110. Helianthemum Tourn.

Homogamous or protogynous pollen flowers, of which all the stamens are fertile.

326. H. vulgare Gaertn. (=H. Chamaecistus *Mill.*, and Cistus Helianthemum *L.*). (Herm. Müller, 'Fertilisation,' p. 117, 'Weit. Beob.,' II, p. 210, 'Alpenblumen,' pp. 161–2; MacLeod, 'Pyreneenbl.,' pp. 124–5; Knuth, 'Bloemenbiol. Bijdragen';

Warnstorf, Verh. bot. Ver., Berlin, xxxvii, 1895, xxxviii, 1896.)—The citron-yellow, or more rarely white pollen flowers, expand in the sunshine into a disk of from 25 to over 30 mm. in diameter. The numerous stamens radiate from the simultaneously mature stigma, so as to be tolerably far removed from it. Cross-pollination is consequently effected by insects alighting in the middle of the flower and bringing with them pollen from other blossoms. Even when the flower is half closed the pollen-covered anthers touch the stigma, so that automatic self-pollination necessarily takes place if insect-visits fail. The flowers close completely at night and during rainy weather.

Warnstorf describes the flowers as homogamous or protogynous. The thick greenish stigma is often mature before the flower has fully expanded. The pollen-grains are of a beautiful dark yellow colour, biscuit-shaped, with a longitudinal groove, and covered by lines of very delicate tubercles; about 75 μ long and 31 μ broad.

VISITORS.—MacLeod observed 7 of the smaller bees, 10 Diptera, 2 Lepidoptera (vainly attempting to suck), and 5 beetles, in the Pyrenees. Hermann Müller saw 5 beetles, 19 Diptera, 13 Hymenoptera, and 16 Lepidoptera, in the Alps. Loew noticed a hover-fly—Merodon cinereus *F.* po-dvg.

Hermann Müller (H. M.) and myself (Kn.) observed the following in Central and North Germany.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (H. M.); 2. A. quadripunctata *L.* (H. M.). (*b*) *Bruchidae*: 3. Spermophagus cardui *Stev.*, po-dvg. (?) (H. M.). (*c*) *Cerambycidae*: 4. Strangalia nigra *L.*, dvg. the anthers (H. M.). (*d*) *Mordellidae*: 5. Mordella aculeata *L.*, vainly skg. (H. M.). (*e*) *Oedemeridae*: 6. Oedemera virescens *L.*, po-dvg. (H. M.). (*f*) *Telephoridae*: 7. Dasytes plumbeus *Müll.*, po-dvg. (H. M.). **B. Diptera.** *Syrphidae*: 8. Ascia podagrica *F.*, po-dvg. (H. M.); 9. Chrysotoxum fasciolatum *Deg.*, po-dvg. (H. M.); 10. Eristalis nemorum *L.*, po-dvg. (Kn.); 11. Helophilus pendulus *L.*, po-dvg. (H. M., Kn.); 12. Melithreptus scriptus *L.*, po-dvg. (H. M.); 13. M. taeniatus *Mg.*, po-dvg. (H. M., Kn.); 14. Merodon aeneus *Mg.*, po-dvg. (H. M.); 15. Syrphus pyrastri *L.*, po-dvg. (H. M.); 16. S. ribesii *L.*, po-dvg. (H. M., Kn.). **C. Hymenoptera.** *Apidae*: 17. Andrena fulvicrus *K.* ♀, po-cltg. (H. M.); 18. Apis mellifica *L.* ☿, freq., po-cltg. (H. M., Kn.); 19. Bombus lapidarius *L.* ☿ and ♀, po-cltg. (Kn.); 20. B. agrorum *F.* ☿, po-cltg. (H. M.); 21. Halictus sp., po-cltg. (Kn.); 22. H. villosulus *K.* ♀, po-cltg. (H. M.); 23. Prosopis annularis *Sm.* ♀ (=P. panzeri *Först*, according to Dalla Torre), po-cltg. (H. M.). **D. Lepidoptera.** 24. Melithaea athalia *Rott.*, trying to suck on the wing (H. M.).

Willis ('Fls. and Insects in Gt. Britain,' Part II) observed the Muscid Anthomyia radicum *L.*, very abundant, po-dvg., on the seaboard of South Scotland. In Dumfriesshire numerous Diptera were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 20).

Schletterer observed the following *Apidae* at Pola in the Tyrol:—1. Andrena parvula *K.*; 2. Bombus derhamellus *K.*; 3. Halictus calceatus *Scop.*; 4. H. morio *F.*; 5. Melitta melanura *Nyl.*

327. **H. alpestre** DC. (Herm. Müller, 'Alpenblumen,' pp. 160–2; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 310.)—The expanded flower is 12–20 mm. in diameter, and its mechanism essentially agrees with that of the last species. Müller describes the plant as homogamous, Kerner as feebly protogynous. The stamens

are sensitive, and this favours cross-pollination. Automatic self-pollination is effected by closure of the flowers at night and during dull weather.

VISITORS.—These are similar to those of H. vulgare in the Alps (Herm. Müller), but owing to the smaller size of the flowers are less numerous and belong to fewer species.

328. **H. Fumana** Mill. (Schulz, 'Beiträge,' II, pp. 17–18.)—Schulz states that the yellow flowers are homogamous and of variable size. They open only in the forenoon during sunshiny weather. At first self-pollination is prevented by the position of the stigma, but as the stamens move inwards either spontaneously or by insect agency, so as to touch it, automatic self-pollination can be effected.

VISITORS.—Schulz observed bees, flies, and more rarely beetles, in the South Tyrol.

329. **H. oelandicum** Wahlenb. (=H. vineale *Pers.*).—Schulz ('Beiträge,' II, p. 18) describes the flowers as homogamous. They are smaller than those of the last species, but not so ephemeral. As the style is less bent than in H. Fumana, there is either contact between anthers and stigma at the beginning of anthesis or the stigma is placed so that pollen falls upon it.

VISITORS.—Schulz observed flies, bees, and beetles.

MacLeod saw a Syrphid visiting the yellow pollen flowers in the Pyrenees.

330. **H. guttatum** Mill. (Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney.')—The citron-yellow flowers open only for a forenoon. There are usually dark-brown pollen-guides on the bases of the petals. The anthers being at a higher level than the large whitish stigma, automatic self-pollination by the fall of pollen can easily take place. It is inevitable after the petals have been shed, for the sepals then close together so as to press the anthers against the stigmas, to which they remain clinging as the fruit matures. Linnaeus ('Amoenitates,' III, p. 396) observed cleistogamy in plants brought from Spain and cultivated in Upsala.

331. **H. salicifolium** Pers.—Linnaeus (op. cit.) observed at Upsala that ripe fruits were produced when the flowers remained closed.

VISITORS.—Schletterer noticed the small bee Halictus morio *F.* at Pola.

332. **H. polifolium** DC.—Briquet ('Études d. biol. flor. d. les Alpes occident.') states that the flowers open and close repeatedly, owing to movements of the sepals. The bases of the white petals are of a citron-yellow colour. The numerous yellow stamens are crowded into a bundle in the middle of the flower; their anthers are introrse, but while shedding their pollen turn their dehisced sides more or less outwards. There is no nectar. The style is curved like the letter *S*, and the stigma is large. The irritability of the filaments—which has long been known—persists throughout anthesis, and affects all the stamens equally. It is most marked in dry weather at a temperature of 18–25° C. Within 1–5 seconds after a filament is touched it has passed from an almost erect position into a nearly horizontal one, owing to the bending of a zone about ½ mm. long immediately above its insertion. After about 15 seconds it gradually resumes its original position, and can then be stimulated afresh. The motile mechanism resembles that of the pulvini of Mimosa leaves. Its oecological significance is found in the fact that when insects (humble-

bees and bees) alight upon the corolla they irritate the stamens, which move outwards and dust them with pollen, that they frequently transfer to the stigmas of other flowers, *especially those in which the style protrudes laterally from the bundle of* stamens. Automatic self-pollination is usually excluded, for the stigma projects 0·5–0·7 beyond the anthers of the surrounding stamens. Besides the ordinary plants with hermaphrodite flowers only, andromonoecious ones have been observed, bearing male flowers in the proportion of one to fifty or eighty of the usual kind. Kirchner says that the male flowers are smaller than the others, with fewer stamens, and no pistil.

333. **H. canum** Dun.—According to Briquet (op. cit.), the protogynous pollen flowers of this species, which are visited by humble-bees and bees, open and close by movement of the sepals. The filaments are not irritable. The diameter of the bright yellow corolla is 12–13 mm. when fully expanded. Kirchner says that automatic self-pollination very rarely takes place, as the flowers are protogynous and the anthers extrorse.

334. **H. kahiricum** *Delile*, and 335. **H. Lippii** *Pers*.—These two Egyptian species frequently possess cleistogamous flowers, according to Ascherson (Bul. soc. linn., Paris, i, 1880, pp. 250–1; Sitzber. Ges. natf. Freunde, Berlin, 1880, pp. 97–108).

336. **H. villosum** Thib., and 337. **H. ledifolium** L.—Ascherson (Sitzber. Ges. natf. Freunde, Berlin, i, 1880) says that the flowers of these species open and are cross-pollinated only in the morning. If crossing is not then effected, self-pollination is brought about by closure of the flower. The same applies to species of the genus

III. Cistus Tourn.

338. **C. hirsutus** L. and 339. **C. villosus** L.

Visitors of C. villosus.—Schletterer observed the following bees, po-cltg., at Pola.—

1. Andrena convexiuscula *K.*; 2. A. cyanescens *Nyl.*; 3. A. nana *K.*; 4. Halictus calceatus *Scop.*, var. obovatus *K.*; 5. H. fasciatellus *Schenck*; 6. H. interruptus *Pz.*; 7. H. levigatus *K.* ♂; 8. H. minutus *K.*; 9. H. quadrinotatus *K.*; 10. H. scabiosae *Rossi*; 11. H. tetrazonius *Klug*; 12. H. varipes *Mor.*

340. **C. monspeliensis** L.—

Visitors.—Schletterer observed the following bees at Pola.—

1. Andrena cyanescens *Nyl.*; 2. A. morio *Brull.*; 3. A. nana *K.*; 4. Ceratina cucurbitina *Rossi*; 5. Colletes lacunatus *Dours*; 6. Halictus calceatus *Scop.*; 7. H. minutus *K.*; 8. H. morio *F.*; 9. H. quadrinotatus *K.*; 10. H. scabiosae *Rossi*; 11. Prosopis clypearis *Schenck*; 12. P. genalis *Ths.*; 13. P. variegata *F.*

341. **C. salvifolius** L. (Knuth, 'Bl. u. Insekt. a. d. Ins. Capri.')—The flower—which smells slightly of jessamine—expands in the sunshine into a disk 5 cm. in diameter. There are yellow pollen-guides on the bases of the white petals. The anthers of the numerous stamens have already dehisced when the flower opens, and the large capitate, strongly papillated stigma is simultaneously mature. The stamens at first lie upon the recurved petals, but subsequently become erect, so that the anthers are brought above the stigma, when automatic self-pollination may take

place by the fall of pollen. This kind of pollination is inevitable when the flowers close at night, or in dull weather.

VISITORS.—In Capri I noticed that a beetle—Oxythyrea squalida *Scop.*—was the almost exclusive visitor and pollinator, the pollen readily adhering to its hairy body. Less frequently a bee of medium size—Halictus sp.—made its appearance and collected pollen on the tibiae of its hind-legs. Both insects usually first alighted on the stigma, and therefore effected cross-pollination.

Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena cyanescens *Nyl.*; 2. A. dubitata *Schenck*; 3. A. nana *K.*; 4. A. parvula *K.*; 5. Halictus interruptus *Pz.* (*b*) *Pompilidae*: 6. Pompilus rufipes *L.* (*c*) *Tenthredinidae*: 7. Amasis laeta *F.*

XIII. ORDER *VIOLARIEAE* DC.

The most important genus of this order is—

112. **Viola** *Tourn.*

The species of this genus mostly possess large brightly-coloured flowers, in which yellow, violet, and blue predominate. The anterior (lower) petal is spurred, giving the flowers their characteristic form, from which alone we might infer that they were adapted to particular groups of insects. Most species of violets and the like are bee flowers, Diptera and Lepidoptera playing a comparatively unimportant part as pollinators. In certain species, however—e. g. V. calcarata—the spur is so long that only the proboscis of Lepidoptera can reach the nectar. There are, on the other hand, violets with so short a spur—e. g., V. biflora—that they must be described as fly flowers. The species of Viola therefore chiefly belong to the flower class **Hb**, but some of them are included in the classes **L** and **F**. All are homogamous.

The anther of each of the two lower stamens possesses—as Sprengel long ago admirably described—a nectar-secreting process, which projects into the spur of the corolla where the secretion is stored. The connective of each of the five stamens is produced into a membranous appendage. As these appendages overlap one another laterally and also clasp the style underneath the stigma, they form a conical chamber, into which the dry pollen falls when the anthers dehisce. The stigma projects beyond this cone, and closes the entrance to the flower, so that an insect probing for nectar must first touch it, and then raise it up so as to open the anther cone, from which pollen falls on to the upper surface of its proboscis. And since visitors are in the habit of thrusting the proboscis only once into each flower, they must regularly effect cross-pollination. In many species cleistogamous flowers with vestigial corollas have been observed, as well as the ordinary open ones. (Cf. Vol. I, pp. 51, 58.)

342. **V. odorata** L. (Sprengel, 'Entd. Geh.', p. 394; Herm. Müller, 'Fertilisation,' p. 119, 'Weit. Beob.,' II, p. 209; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 200; Schulz, 'Beiträge,' II, p. 205; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 221–2, Arch. biol., Paris-Bruxelles, vii, 1886; Knuth, 'Bloemenbiol. Bijdragen'; Kirchner, 'Flora v. Stuttgart,' p. 318; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The inconspicuousness

of the dark-blue flowers, which are almost hidden by the leaves, is partly compensated for by their powerful fragrance. The corolla is whitish in the middle, the white patch on the lower (spurred) petal being traversed by dark-blue veins, which converge to the opening of the spur, and serve as nectar-guides. The end of the style—which bears the stigma—is dilated distally, bent down like a hook, and at some little distance from the lower petal. MacLeod states that a fluid is secreted in the stigmatic cavity, a drop of it being pressed out when an insect pushing into the spur touches and raises the stigma. This drop moistens the head of the insect and prepares it for the reception of the dry, white, smooth pollen, of which the separate grains are about 44 μ long and 25 μ broad.

According to Hildebrand and Kerner, the lobe on the under-side of the stigmatic cavity is covered with pollen when an insect visitor pushes its proboscis into the flower, and when this is withdrawn the lobe is pressed up against the head of the stigma so as to introduce the pollen into its cavity.

Visitors.—Bees are the most important visitors. Sprengel depicts the honey-bee as the pollinator on the title-page of his 'Entdeckte Geheimnisse'; and as a matter of fact it is the most frequent visitor of this violet. Long-tongued bees have also been observed—especially by Hermann Müller—sucking nectar and effecting cross-pollination. This may also be regularly brought about, though more rarely, by Bombyliidae and butterflies (Vanessa, Rhodocera), which are attracted by the pleasant odour and suck the nectar. Cross-pollination is essential to the chasmogamous flowers, for Sprengel's experiments long ago proved that no fruits are set if insects are excluded. Short-tongued humble-bees occasionally bite through the spur and steal the nectar (Schulz).

Kirchner states that—should insect-visits fail—cleistogamous flowers are developed on the runners during August. These are axillary, with peduncles 3–5 cm. long, and are bent downwards, sometimes even penetrating the loose soil. Within the closed calyx there are five small pale petals folded as in a bud, five stamens with small non-dehisced anthers, the pollen-grains of which send out tubes that penetrate the stigma. These cleistogamous flowers are fertile: their capsules bury themselves in the earth—when this is loose enough—and there ripen.

The following insects have been observed by Hermann Müller (H. M.) in Westphalia, by Buddeberg (Budd.) in Nassau, and by myself (Kn.) in Schleswig-Holstein.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes (H.M.). **B. Diptera.** *Bombyliidae*: 2. Bombylius discolor *Mikan*, skg. (H. M.). **C. Hymenoptera.** *Apidae*: 3. Andrena fulva *Schr.* ♀, vainly skg. (H. M.); 4. Anthophora pilipes *F.* ♂, skg. (H. M.); 5. Apis 1 ellifica *L.* ☿, skg. and po-cltg. (?) (H. M., Kn.); 6. Bombus derhamellus *K.* ♀ (H. M.); I B. hortorum *L.* ♀ (H. M.); 8. B. lapidarius *L.* ♀, skg. (H. M., Kn.); 9. Halictus eatus *Scop.* ♀, vainly skg. (H. M.); 10. Osmia cornuta *Latr.* ♀, skg. (H. M.); 11. whi ifa *L.* ♀ and ♂, very freq., skg. (H. M., Budd.). **D. Lepidoptera.** *Rhopalocera*: dian Rhodocera rhamni *L.*, skg. (H. M.); 13. Vanessa cardui *L.*, very freq., skg. anthers 14. V. urticae *L.*, skg. (H. M.).

the large c deknecht noticed the following bees in Thuringia:—1. Bombus jonellus at first lie 3. pratorum *L.* ♀; 3. Osmia bicolor *Schr.* ♀; 4. O. uncinata *Gerst.*; anthers are v Osmia rufa *L.* ♂, in Nassau; and Alfken observed 8 bees at Bremen,

i.e.:—1. Andrena albicans *Müll.* ♂; 2. A. albicrus *K.* ♂; 3. A. praecox *Scop.* ♂; 4. Bombus lapidarius *L.* ♀; 5. B. lucorum *L.* ♀; 6. B. terrester *L.* ♀; 7. Osmia rufa *L.* ♀ and ♂; 8. Podalirius acervorum *L.* ♀.

MacLeod observed Apis, 4 long-tongued bees, 2 short-tongued bees, and 3 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 222).

Friese records the following bees for Fiume (F.), Innsbruck (I.), Mecklenberg (M.), Trieste (T.), and Hungary (H.):—1. Osmia acuticornis *Duf. et Pér.* (= O. dentiventris *Mor.*, and O. hispanica *Schmiedekn.*) (F., T., H.); 2. O. bicolor *Schr.* ♀, skg. (M., sometimes H.); 3. O. cornuta *Ltr.* (I.); 4. O. pilicornis *Sm.* (T., H., occasionally M.); 5. O. rufa *L.* (M.).

343. **V. hirta** L.—Kirchner states that the mechanism of the odourless brightly coloured flowers essentially agrees with that of V. odorata ('Flora v. Stuttgart,' p. 318). They are mostly infertile. Schulz observed that the spur was sometimes bitten through by humble-bees. The cleistogamous flowers—according to Kirchner—resemble those of the last species.

Warnstorf describes the pollen-grains as white, irregularly ellipsoidal, smooth, about 37 μ long and 25–30 μ broad.

Calloni says that the variety Salvatoriana possesses both chasmogamous and cleistogamous flowers. The former are visited by bees and butterflies (Argynnis).

344. **V. collina** Bess.—Kerner says there are cleistogamous flowers in this species. Schulz observed that the spurs of the chasmogamous flowers were sometimes perforated by humble-bees.

345. **V. sylvatica** Fr. (= V. sylvestris *Lam.*, in part).—The mechanism of the odourless flowers is similar to that of the last species, according to Müller ('Fertilisation,' p. 119). The corolla is violet, with a spur 7 mm. long of somewhat darker colour. Kirchner states that the cleistogamous flowers of this species—which were discovered by Corry and Bennett—agree in structure with those of V. odorata, but the tips of the sepals are bent outwards.

Visitors.—Herm. Müller observed the following, all skg.—**A. Hymenoptera.** *Apidae*: 1. Bombus agrorum *F.* ♀. **B. Diptera.** *Bombyliidae*: 2. Bombylius discolor *Mikan.* **C. Lepidoptera.** *Rhopalocera*: 3. Pieris brassicae *L.*; 4. P. rapae *L.*; 5. P. napi *L.*; 6. Rhodocera rhamni *L.*; 7. Anthocharis cardamines *L.*

346. **V. Riviniana** Reichb.—The flower mechanism agrees with that of V. sylvatica, but the corolla is larger and of a brighter blue, and the spur is yellowish-white. Kirchner states that there are both chasmogamous and cleistogamous flowers.

Visitors.—I observed at Kiel a nect-skg. humble-bee—Bombus agrorum *F.* ♀.

347. **V. canina** L. (Herm. Müller, 'Fertilisation,' p. 121, 'Weit. Beob.,' II, p. 209; MacLeod, 'Bot. Jaarb. Dodonaea,' Ghent, vi, 1894, pp. 222–3, Arch. biol., Paris-Bruxelles, vii, 1886; Kirchner, 'Flora v. Stuttgart,' p. 320; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 33.)—The flower mechanism agrees with that of V. odorata. MacLeod describes the stigma as swollen in the bud, with a wide opening and a small valve; it subsequently grows in a straight line, and finally bends round into a hook. Failing insect-visits, the flowers are infertile (Darwin). According to Kirchner, the cleistogamous flowers are situated as in V. odorata, but the petals have almost completely disappeared, while the stamens are very small, and only the

two lower ones possess anthers, which are small and contain but little pollen. The pollen-grains send out pollen-tubes through an opening at the upper end of each anther-lobe. The capsules of the cleistogamous flowers ripen much more rapidly than those of the chasmogamous ones.

VISITORS.—I observed a humble-bee, a butterfly (Pieris), and Podalirius acervorum *L.* at Kiel; all skg. I saw a humble-bee—Bombus lapidarius *L.*—in Sylt, skg. the var. flavicornis *Sm.*, which has conspicuous dark flowers with bright orange spurs.

Hermann Müller observed the following in Westphalia and Thuringia.—

A. Diptera. *Bombyliidae*: 1. Bombylius discolor *Mikan*, ♀, skg. (?); 2. B. major *L.*, skg. **B. Hymenoptera.** *Apidae*: 3. Bombus lapidarius *L.* ♀, skg.; 4. B. terrester *L.* ♀, skg. (Thuringia); 5. Osmia bicolor *Schr.* ♀, skg.; 6. O. rufa *L.* ♂, skg. **C. Lepidoptera.** *Rhopalocera*: 7. Anthocharis cardamines *L.*, skg.; 8. Pieris brassicae *L.*, skg.; 9. P. napi *L.*, skg.; 10. P. rapae *L.*, skg.; 11. Rhodocera rhamni *L.*, skg.

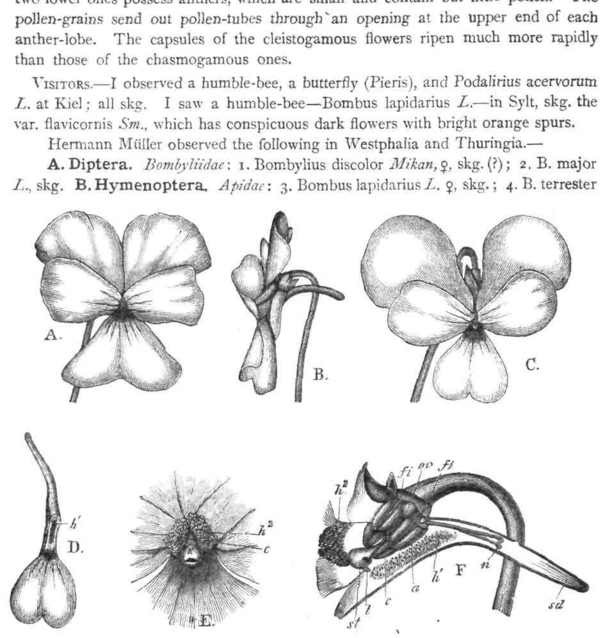

FIG. 37. *Viola calcarata*, *L.* (after Herm. Müller). *A.* Front view of flower from Piz Umbrail. *B.* Side view of the same. *C.* Front view of flower from Albula. *D.* Lower lip of the same with the nectar-spur. *E.* Front view of the entrance of *A.* *F.* Section of *A.* *a*, anthers; *c*, appendages of the connectives; h^1, pollen-collecting hairs; h^2, hairs which in bee-pollinated species of Viola help the bees to cling to the flower: here they are useless vestiges; *k*, stigma; *l*, lip-like appendage below the entrance (*st*) to the cavity of the stigma; *sd*, nectar receptacle. (*A—D* natural size; *E F* × 3½.)

Alfken saw the following 4 bees at Bremen:—1. Bombus arenicola *Ths.* ♀; 2. B. derhamellus *K.*; 3. B. muscorum *F.* ♀; 4. Podalirius acervorum *L.* ♀.

Verhoeff observed the following in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes coracinus *St.*, in perforated spurs. **B. Hymenoptera.** (*a*) *Apidae*: 2. B. lapidarius *L.* ♀, skg.; 3. B. terrester *L.* ♀, skg.; 4. Osmia maritima *Friese*, one ♀; 5. Psithyrus vestalis *Fourcr.* ♀, skg. **C. Lepidoptera.** *Pieridae*: 6. Pieris brassicae *L.*, 2 ♀.

MacLeod noticed 3 humble-bees, Anthophora, an ant, and a beetle in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 223).

Burkill ('Fertlsn. of Spring Fls.') observed the following on the Yorkshire coast.—

A. Diptera. *Muscidae*: 1. Cephalia nigripes *Mg.*, skg. **B. Hymenoptera.** *Apidae*: 2. Bombus terrester *L.*, skg.

In Dumfriesshire 2 humble-bees, an Empid, and a hover-fly have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 21).

348. **V. canina × stagnina** Ritschl. (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Both chasmogamous and cleistogamous flowers are present. The former are borne on distinctly four-winged peduncles, up to 70 mm. in length. They are bright blue; the lower and two lateral petals are marked with dark violet veins; the spur is blunt, grooved at the tip, greenish-yellow, quite or nearly as long as the appendages of the sepals; the stigma projects 1 mm. beyond the cone of anthers. The cleistogamous flowers—which are situated in the leaf-axils of the upper branches—have very short peduncles, are destitute of corolla, and the anthers of their broad leaf-like stamens are extremely small. The spurs of the chasmogamous flowers are almost always broken.

349. **V. calcarata** L.—This species bears Lepidopterid flowers (Herm. Müller, 'Alpenblumen,' pp. 154–6), with a spur 13–25 mm. long (Fig. 37). The nectar is concealed in the end of the spur, and is only readily accessible to Lepidoptera. Autogamy is excluded. Kerner says that the flowers are blue in the West-Central Alps and yellowish in Carniola.

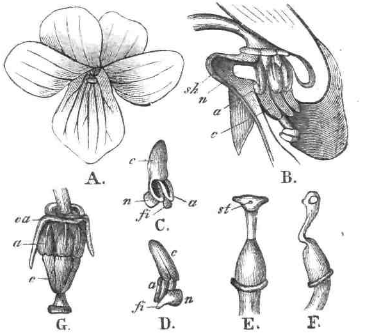

FIG. 38. *Viola biflora, L.* (after Herm. Müller). *A.* Front view of flower (× 3½). *B.* Section of flower, omitting the nectar-guides (× 7). *C.* One of the stamens with a nectary (*n*), seen from the inner side. *D.* Outer side of the same. *E.* Pistil seen from below, *F.* Lateral view of the same. *G.* Stamens and pistil, seen from above. *fi*, filament: *a*, anther; *c*, appendage of connective: *n*, nectary.

Visitors.—These are partly moths, partly butterflies, according to the length of the spur. The varieties with the longest spurs can only be properly sucked by a diurnal moth—Macroglossa stellatarum *L.*, with a proboscis 25–8 mm. long. This insect appears to be the most successful pollinator. Hermann Müller, for instance, saw it visit and pollinate in $6\frac{3}{4}$ minutes, no less than 194 flowers belonging to different plants.

350. **V. biflora** L.—This species bears fly-flowers (Herm. Müller, 'Alpenblumen,' pp. 152–4). The spur is so short that a proboscis not more than 2 or 3 mm. long

can reach the nectar (Fig. 38). The flowers are, in fact, chiefly visited by flies. It has yet to be determined whether automatic self-pollination can take place should insect-visits fail.

Lindman observed on the Dovrefjeld flowers exhibiting a transition to cleistogamy, in addition to the chasmogamous ones, which resemble those of the Alps. In these the lateral petals, and sometimes even the anterior ones, are greatly reduced. In individual flowers the style may be very short, so that the pollen-surrounded stigma occupies the position which is usual in cases of cleistogamy.

VISITORS.—Herm. Müller observed the following in the Alps.—(*a*) Flies, particularly *Syrphidae*—7 species—which sucked from above, and regularly effected cross-pollination; the larger *Muscidae* behaved similarly. (*b*) Short-tongued bees—Halictus cylindricus *F.*—which first attempted to suck from below, but quickly learned the proper way of securing nectar from above. (*c*) A few Lepidoptera, skg.

MacLeod noticed 2 Muscids in the Pyrenees ('Pyreneenbl.,' pp. 398–9).

351. **V. lutea** Sm.—

VISITORS.—Willis and Burkill ('Fls. and Insects in Gt. Britain,' Part 1) observed the following Muscids in Central Wales:—1. Anthomyia sp.; 2. Hylemyia lasciva *Zett.*, skg.; 3. Siphona geniculata *Deg.*, skg.

Wittrock noticed near Stockholm—on the variety grandiflora *Vill.*—humble-bees and Lepidoptera.

352. **V. sepincola** Kern.—Kerner states that the flowers of this species are chasmogamous in sunny places, but cleistogamous in shady woods. Both hemicleistogamous and eucleistogamous flowers occur, according to Calloni (Bul. Soc. bot., Genève, v, 1889).

353. **V. sciaphila** Koch.—Calloni states that in this species there are hemicleistogamous or eucleistogamous flowers, in addition to the chasmogamous ones which appear in spring.

354. **V. stagnina** Kit.—Corry says that this species possesses cleistogamous flowers.

355. **V. montana** L.—Linnaeus long ago observed cleistogamous flowers in this species.

356. **V. elatior** L., and 357. **V. lancifolia** L.—Both these species bear cleistogamous flowers, according to Daniel Müller (Bot. Ztg., Leipzig, xxv, 1867).

358. **V. bicolor** L.—Hermann Müller ('Fertilisation,' p. 121) states that there are cleistogamous flowers in this species.

359. **V. mirabilis** L.—There are cleistogamous flowers in this species, according to Dillenius.

360. **V. palustris** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 33.)—The *small flowers are of a bright lilac colour, and the lower petal is streaked with dark* violet.

VISITORS.—In Dumfriesshire a Muscid has been observed (Scott-Elliot, 'Flora of Dumfriesshire,' p. 20).

361. **V. cornuta** L.—*The flower exhales a strong odour at night*, and, according to Hart ('Fertlsn. of Viola tricolor and V. cornuta'), is adapted for pollination by moths. The spur is longer than the corolla.

VISITORS.—Hart observed an owlet-moth—Cucullia umbratica *L.*—a butterfly—Hipparchia janira *L.*—and humble-bees.

Wittrock noticed Bombus subterraneus *L.* and several butterflies near Stockholm.

362. **V. pinnata** L. (Herm. Müller, 'Alpenblumen,' p. 151.)—The lower lip possesses no hairs for the reception of the pollen which falls from the cone of anthers. The proboscis of an insect when thrust into the spur is, therefore, not covered with pollen from below, but from above, so that the lower margin of the stigma is pollinated and crossing is effected. Self-pollination is prevented by a pronounced broadening of the rim of the stigma (see Fig. 39). Linnaeus long ago observed cleistogamous flowers.

VISITORS.—These are probably bees.

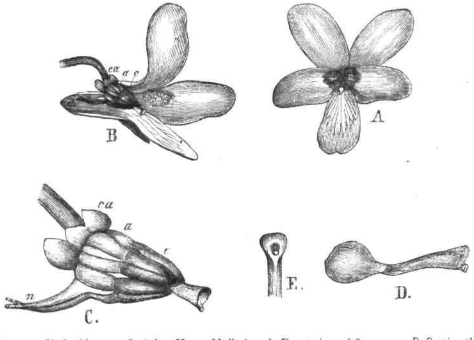

FIG. 39. *Viola pinnata, L.* (after Herm. Müller). *A.* Front view of flower. *B.* Section through flower. *C.* Reproductive organs. *D.* Pistil seen from the side. *E.* Front view of style and stigma. (*A* and *B* ×3½; *C–E* ×7.)

363. **V. arenaria** DC. (Herm. Müller, 'Alpenblumen,' p. 152.)—The flower mechanism agrees with that of the last species. The proboscis of an insect is dusted with pollen from above, and self-pollination is prevented. The margin of the stigma is not expanded, but beset with stiff, projecting hairs (see Fig. 40).

At Kongsvold on the Dovrefjeld Lindman found that the flowers were cleistogamous during the first three weeks of July, and set fruits. Kerner observed in the Tyrol cleistogamous flowers on the prostrate runners, besides the chasmogamous ones.

VISITORS.—Herm. Müller observed butterflies (Vanessa).

364. **V. tricolor** L. (Sprengel, 'Entd. Geh.,' pp. 386–400; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.'; Herm. Müller, 'Fertilisation,' pp. 117–18, 'Weit. Beob.,' II, pp. 206–9; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 215–20; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 33, 150; Kirchner, 'Flora v. Stuttgart,' p. 320.)—Hermann Müller says that to get at the nectar insects must introduce their proboscis immediately below the spheroidal stigmatic head, and so on into the spur.

This head, however, rests on a hair-fringed groove in the lower petal, into which the pollen falls either of itself or owing to the pressure of the insect. The proboscis—as it passes along the groove—gets dusted with pollen on its under-side. The three following varieties may be distinguished.—

(*a*) *V. vulgaris* Koch. This variety possesses large flowers, 20–30 mm. long and 14–16 mm. broad. The petals are longer than the calyx, and are either all violet, or the four upper ones are violet, while the lower one is yellow with violet veins; or else the lateral petals may also be yellowish. This variety can only be fertilized by cross-pollination. The opening of the spheroidal stigmatic head is turned outwards, so that the pollen, when it escapes from the anther-cone, cannot of itself fall into the stigmatic cavity. On the lower edge of the stigma there is a flexible lip-like valve, which prevents the proboscis of an insect as it is being withdrawn from effecting self-pollination. When—on the other hand—the proboscis is introduced, it may dust the upper-side of the valve with pollen from another flower, thus bringing about

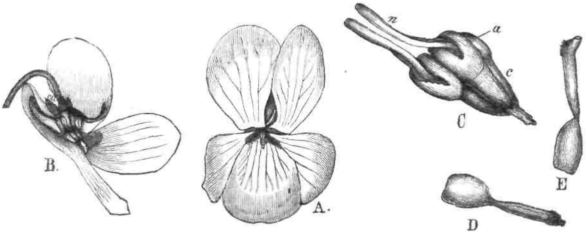

FIG. 40. *Viola arenaria*, *DC* (after Herm. Müller). *A* and *B*, as in Fig. 39. *C*. Reproductive organs, seen from below. *D* and *E*. Pistil seen from below and from the side. (*A* and *B* × 2⅓; *C*—*E* × 7.)

cross-pollination. After the flower has been open a few days the pollen falls of itself out of the anther-cone into the hairy groove of the lower petal. If insect visitors are kept away, the flowers do not wither for two or three weeks, and either no fruits are set, or only a few with seeds incapable of germinating.

VISITORS.—I have seen Anthophora pilipes *F.*, and Bombus hortorum *L.*, both skg., in this large-flowered variety. Hermann Müller observed only long-tongued bees:—Apis, Bombus lapidarius, B. terrester, B. hortorum, and Anthophora pilipes *F.* ♀; all skg. The last-named bee was also noticed by Delpino.

As further visitors Herm. Müller observed a small bee—Andrena albicans *Müll.* ♂—with a proboscis 2–2½ mm. long. Self-pollination was effected during its fruitless attempts to reach the nectar, which was concealed at a depth of 3 mm. He also observed a hover-fly—Syritta pipiens *L.*—po-dvg., which frequently touched the stigma, and must therefore have effected self-pollination.

On one occasion Alfken noticed a humble-bee—Bombus hortorum *L.*—skg., in Juist.

Verhoeff observed the following in Norderney and Juist (J).—

A. Hymenoptera. (*a*) *Apidae*: 1. Bombus cognatus *Steph.* (=B. muscorum *F.*), one ♀, skg. (J.); 2. B. lapidarius *L.* ♀, skg.; 3. B. latreillelus *K.* (=B. subterraneus *L.*), 2 ♀; 4. B. terrester *L.* 2 ♀, skg., ☿ unusual; 5. Psithyrus vestalis *Fourcr.* one ♀, skg. (*b*) *Vespidae*: 6. Odynerus parietum *L.* one ♀, skg. perforated spurs. **B. Lepidoptera.** *Pieridae*: 7. Pieris brassicae *L.* 4 ♀, one ♂, skg.

Friese records Podalirius acervorum *L.* for Central Europe.

Dalla Torre and Schletterer noticed Bombus hortorum *L.* ♂ in the Tyrol.

The second morphological and oecological variety is:

(β) *V. arvensis* Murr. The flowers are 8–13 mm. long, and 6–8 mm. broad The petals are small, hardly as long as the calyx, and yellowish-white in colour, though more rarely the upper petals are bluish or violet, and the lower one dark yellow. The nectar guides are more or less reduced. This variety is autogamous and autocarpous. The opening of the spheroidal stigmatic head is turned inwards, enabling pollen-grains to fall into it. The lip-like valve is wanting, so that the proboscis of an insect when being withdrawn may effect self-pollination, which is effective.

VISITORS.—I saw the following insects, all skg., on the small-flowered variety of the pansy at Kiel:—the honey-bee, Anthophora pilipes *F.* ♂, Bombus agrorum *F.*, and a white cabbage-butterfly (Pieris napi *L.*). Hermann Müller observed the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes. **B. Diptera.** *Syrphidae*: 2. Rhingia rostrata *L.*, skg. **C. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg.; 4. Bombus hortorum *L.* ♀, skg.; 5. B. agrorum *F.* ♀, skg.; 6. B. rajellus *K.* ♀, skg.; 7. Osmia rufa *L.* ♂, skg. on the wing. **D. Lepidoptera.** *Rhopalocera*: 8. Pieris napi *L.*, skg.; 9. P. rapae *L.*, skg.; 10. Polyommatus dorilis *Hfn.*, skg.

Loew noticed the following in Silesia ('Beiträge,' pp. 34–5).—

A. Hymenoptera. *Apidae*: 1. Diphysis serratulae *Pz.* ♂, skg. **B. Lepidoptera.** *Rhopalocera*: 2. Pieris brassicae *L.*, skg.

MacLeod observed a wasp, and a Lepidopterid, in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1896, p. 220), and—in the Pyrenees—a hover-fly vainly endeavouring to penetrate into the flower (op. cit., iii 1893, p. 398).

Schneider (Mus. Aarsh., Tromsø, 1894) saw B. pratorum *L.* ☿, and B. terrester *L.* ☿, on garden plants in arctic Norway. Wittrock noticed only Apis mellifica *L.* as a cross-pollinator near Stockholm.

The third variety is—

(γ) *V. alpestris.* (Herm. Müller, 'Alpenblumen,' p. 156.) The variety is intermediate between V. tricolor var. vulgaris and V. calcarata (see p. 139). The flowers are 25–30 mm. long, and 18–22 mm. broad when full grown. The spur is intermediate in length between that of V. tricolor (3–4 mm.) and V. calcarata (13–25 mm.). Should insects visit the flowers, crossing is certain, while automatic self-pollination is usually excluded.

VISITORS.—These are intermediate in character between those of the two other varieties, and include Syrphidae, Apidae, and Lepidoptera.

König (SitzBer. Isis, Dresden, (1891) 1892) calls attention to the fact that the large-flowered variety of the pansy is much more variegated than the small-flowered

one, which is usually yellowish-white with ill-developed nectar-guides. The upper petals of the latter form are rarely bluish or violet (cf. p. 143).

Müller says that the blossoms of the small-flowered variety—which are protected against the ravages of insects—wither after two or three days, by which time the fruits have been set. The flowers of the large-flowered variety, on the other hand, do not wither for two or three weeks, and then usually without having set fruits (cf. p. 142).

MacLeod found on sand-dunes in Belgium—at Blankenberge—a variety possessing remarkably large flowers, with black spots on the under-side of the stigma. The stigmatic papillae of this variety are more numerous than in flowers from other habitats.

Wittrock ('Viola-Studier') says that the two constituent parts of the nectar-guide on the odd petal, i.e. the 'nectar-spots' at its base, and the 'nectar-streaks' which radiate forwards from it, are constant in colour in the same variety of the pansy, even though the colour of the petals varies. The nectar-spots are yellow or orange, and the honey-streaks dark violet. The spur is always violet.

The hair-fringed groove on the lower petal serves—according to Wittrock—as a 'pollen-magazine,' in which the falling pollen is collected and stored till an insect visits the flower. The hairs possess knot-like thickenings, which appears to be an adaptation for holding the pollen-grains fast. The front part of the groove forms a 'pollen cavity' open above, while its posterior narrower part constitutes a 'pollen-canal.' The pollen falls into the pollen cavity through an opening between the membranous appendages of the two lowest stamens, which is situated exactly above it.

Wittrock has also demonstrated by direct experiment that the hairs on the bases of the limbs of the lateral petals serve to protect the reproductive organs and the pollen magazine against rain. They are also—as earlier investigators supposed—of use as footholds for pollinating insects.

The petals are much smaller and relatively much broader in the younger flowers than in the older ones.

The flowers of the plant differ according to the season: in spring and early summer the petals are much larger, broader, and more brightly coloured than in late summer. The nectar-streaks are often absent in late summer and autumn, but the nectar-spots and nectaries are constant.

It is exceptional to find flowers of very different colour on the same plant. In one such case that was accurately investigated this peculiarity was limited to the hottest part of the summer, when the colour varied from violet to white. In spring and autumn, on the contrary, the plant produced only violet flowers. Reasoning from this and other cases, Wittrock thinks it probable that a high temperature has an injurious effect upon flower production in the varieties of the pansy, causing smaller and paler blossoms to be developed.

For the first two or three days of anthesis—which lasts about a week—the petals of V. tricolor are nyctitropous. The two upper petals bend forwards in the evening, assuming an almost horizontal position, the lateral petals curve a little inwards, and the lowest petal becomes slightly concave by the upward bending of its edges. Besides these movements—which were overlooked by earlier investi-

gators—mention must be made of the nyctitropous curvature of the peduncle described by Kerner. During the last three or four days of anthesis the nutations of the petals and peduncle are scarcely perceptible.

The anthers do not all dehisce simultaneously. When the flower opens, or even a day earlier, the upper anther opens, the two lateral ones do so a few days later, and the two lower stamens are the last to dehisce.

The pollen-grains are dimorphous or trimorphous; as seen from the front they are quadrangular or triangular, more rarely pentagonal; in side view they are ellipsoidal.

With regard to the functions of the various parts of the female apparatus during pollination, Wittrock arrives at the following conclusions, which differ considerably from those hitherto accepted.—

The form and structure of the stigmatic valve appear not to have been correctly known before, its function being therefore misunderstood. Wittrock describes it as an epidermal outgrowth, short, fan-shaped, and very small, and composed of hyaline club-shaped cells, moderately stiff, and beset with papillae. In the middle part of the valve these cells are arranged in four or five layers, those of the middle layer being the longest, while those of the other layers get successively shorter as the surface is approached. The sides of the lobe are made up of three layers, the cells of the middle one being the longest. Wittrock finds that the valve is only slightly flexible, so that when the proboscis of an insect is withdrawn from the flower it neither closes the stigmatic cavity nor presses pollen into it. The valve therefore plays but a subordinate part in preventing self-pollination during the visits of insects. The knee-like joint in the lower part of the style is much more effective for this purpose. Its elasticity enables the well-known upward curvature of the stigmatic head from the pressure of an insect's proboscis.

Wittrock made observations at Stockholm on the visits of insects to wild plants of V. tricolor *L.*, var. versicolor *Wittr.*, and from these he draws the following main conclusions:—The blossoms of V. tricolor are both Lepidopterid and Hymenopterid flowers in Central Scandinavia. Most insect visitors effect cross-pollination. Among nectar-thieves are a few of the smaller Hymenoptera, e.g. Odynerus oviventris *L.*, and also the fly Ocyptera brassicaria *Fabr.* The beetle Cetonia aurata *L.* devours stamens and petals. The po-dvg. Thysanoptera may in certain cases effect self-pollination. Legitimate insect visitors are few during the height of summer.

In V. arvensis *Murr.* the pollen-magazine is quite open in front, so that there is no sharply-defined pollen-cavity, and the pollen-grains can fall unhindered into the stigmatic cavity. Self-pollination, therefore, regularly takes place. The August flowers are usually entirely devoid of nectar-streaks. In autumn flowers the upper petals are obviously smaller, in proportion to the sepals, than in spring and summer ones. In V. patens, blossoms in which the petals are sometimes greatly reduced may also occur in the earlier parts of the year. These are usually borne on axes of a high order, and possess normally developed and fully functional reproductive organs, even when the petals are reduced to small scales; in this respect, and also in having an open corolla, they differ from cleistogamous flowers.

The busiest visitor observed by Wittrock, in the neighbourhood of Stockholm, was Bombus subterraneus *L.*, which, on account of its activity, may be compared

with the hawk-moth, Macroglossa stellatarum *L.*, rendered famous by Hermann Müller (cf. Vol. I, p. 172; Vol. II, p. 139). (Cf. the review by Grevillius in Bot. Centralbl., Cassel, lxxi, 1897.)

113. **Ionidium** Vent.

Some species of this genus are cleistogamous, according to Bernoulli (Bot. Ztg., Leipzig, xxvii, 1869).

XIV. ORDER *POLYGALEAE* JUSS.

The genus here to be considered is—

114. **Polygala** L.

LITERATURE.—Hildebrand, Bot. Ztg., Leipzig, xxv, 1867, p. 281; Knuth, '*Bl.* u. Insekt. a. d. nordfr. Ins.,' p. 35.

Homogamous bee flowers. The chief means of attracting insects are two large lateral petaloid sepals. The petals are usually of minor importance for this purpose, mainly serving to protect the stamens and pistil. Cleistogamy has also been observed (Kuhn).

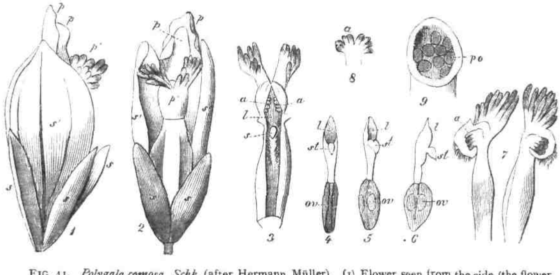

FIG. 41. *Polygala comosa*, *Schk.* (after Hermann Müller). (1) Flower seen from the side (the flower is represented erect instead of in the natural horizontal position): *s*, sepal; *s*[1], one of the two lateral sepals that serve to attract insects; *p*, petal; *p*[1], lower petal provided with digitate appendages, to which the insect clings when it alights. (2) Flower seen from below. (3) Lower petal enclosing the essential organs, seen from above; *a*, anthers; *s*, stigma (with adhesive matter); *l*, spoon-shaped end of the style, which receives the pollen from the adjacent anthers. (4) Pistil, seen from above; *st*, stigma; *l*, spoon-shaped process; *ov*, ovary. (5) The same, seen obliquely from above. (6) The same, seen from the side. (7) The lower petal of a flower just about to expand, split to show the anthers enclosed by it. (8) The coherent anthers. (9) A dehisced anther; *po*, pollen-grains.

Chodat ('Révision et critique des Polygala suisses,' Bul. Soc. Bot., Genève, v, (1888) 1889, pp. 123–85) is of opinion that all the Swiss species of Polygala are capable of self-pollination, i. e. P. vulgaris *L.*, P. comosa *Schk.*, P. amara *Jacq.*, P. calcarea *Schk.*, P. nicaeënsis *Risso*, P. depressa *Wender.*, P. alpina *Long. et Perr.*, and P. Chamaebuxus *L.*

365. P. comosa Schk. (Hildebrand, Bot. Ztg., Leipzig, xxv, 1867; Herm. Müller, 'Fertilisation,' pp. 122–3, 'Weit. Beob.,' II, p. 213, 'Alpenblumen,' p. 169;

Kirchner, 'Flora v. Stuttgart,' pp. 353–4; Schulz, 'Beiträge,' II, pp. 18–19.)—Serrated processes of the lower petal are made use of by insects as an alighting-place. There are two folds on the upper side of the same petal which enclose the anthers and the spoon-shaped end of the style. Behind this 'spoon' is the stigma, a sticky hook-shaped eminence. The anthers are so placed above the end of the style that when they dehisce the pollen necessarily falls into the spoon, where it is stored while the stamens wither. The proboscis of an insect probing for the nectar secreted in the base of the flower must therefore first encounter the pollen in the spoon, and then the stigma. This does not, however, result in self-pollination, for it is not till the proboscis of the insect has been smeared with glutinous matter from the stigma that pollen adheres to it, and this may be carried to the stigma of the next flower visited. Hildebrand states that when insect-visits fail the stigma bends down to the pollen in the spoon far enough to bring about self-pollination. Schulz considers this curvature of the stigma to be an exceptional occurrence, though there is no doubt that the pollen may come into contact with the adhesive stigmatic surfaces. He asserts that self-pollination frequently takes place at the beginning of anthesis, so large a quantity of pollen being discharged from the anthers into the spoon that this is filled up to the level of the stigma, against which some is necessarily pushed by the proboscis of an insect visitor, seeing that the stigmatic surface immediately adjoins the posterior end of the spoon.

VISITORS.—Herm. Müller saw 3 Lepidoptera in the Alps. Buddeberg observed the following in Nassau; all skg.—

A. Hymenoptera. *Apidae*: 1. Andrena albicans *Müll.* ♀; 2. A. fulvago *Chr.* ♀; 3. Eucera longicornis *L.* ♂. **B. Lepidoptera.** *Rhopalocera*: 4. Lycaena sp.

366. **P. vulgaris** L. (Hildebrand, op. cit.; Herm. Müller, 'Fertilisation,' p. 123, 'Weit. Beob.,' II, p. 213; Kirchner, 'Flora v. Stuttgart,' p. 354; Schulz, op. cit.; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 241–6; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 35.)—The flower mechanism agrees with that of the last species.

VISITORS.—The following have been observed by Herm. Müller (H. M.) and myself (Kn.); all skg.—

A. Hymenoptera. *Apidae*: 1. Apis mellifica *L.* (Kn., H. M.); 2. Bombus lapidarius *L.* (Kn., H. M.); 3. B. terrester *L.* (Kn., H. M.). **B. Lepidoptera.** (*a*) *Geometridae*: 4. Odezia chaerophyllata *L.* (H. M.). (*b*) *Rhopalocera*: 5. Polyommatus hippothoë *L.* (H. M.). **C. Diptera.** *Empidae*: 6. Empis livida *L.* (H. M.).

In the Pyrenees MacLeod observed a humble-bee skg. nectar, and a wasp trying to suck it.

367. **P. amara** L.—The flower mechanism of this species agrees with that of P. comosa. Kirchner states that the flowers of the variety *austriaca* Koch are in all respects smaller.

Schulz ('Beiträge,' II, p. 19), in a very large number of cases, was unable to perceive the outward curving of the stigmatic process towards the spoon, which Hildebrand described as taking place towards the end of anthesis.

368. **P. calcarea** Schulz.—

VISITORS.—MacLeod observed a Lepidopterid skg. in the Pyrenees.

369. P. Chamaebuxus L. (Hildebrand, op. cit.; Herm. Müller, 'Alpenblumen,' pp. 165–8.)—Kerner says that the flowers possess a plum-like odour. Their structure—which was first described by Hildebrand—bears a certain resemblance to that of some Papilionaceae (Lotus). In both cases the stamens and style lie in the lower part of the horizontal flower, and bend upwards at the tip. Anthers and stigma occupy a laterally compressed chamber (carina), which is only open above, and this is pressed down by an insect visitor in such a way that not only are the anthers themselves pressed against its body, but also a part of the pollen discharged into the surrounding chamber before anthesis. At the same time the stigma is pressed against the under-surface of the visitor—which is probably a bee—

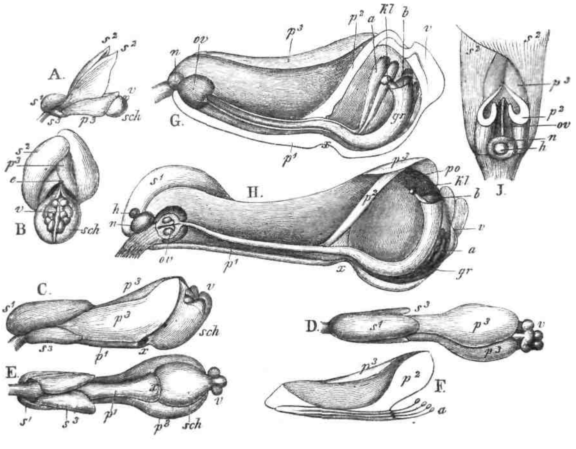

FIG. 42. *Polygala Chamaebuxus*, *L.* (after Herm. Müller). *A.* Flower seen from the side (natural size). *B.* Flower seen from the front (× 2½). *C.* Flower after removal of the two petaloid sepals, seen from the side. *D.* The same, seen from above. *E.* The same, seen from below (× 3). *F.* The two petals of the left side (× 2½). *G.* Bud, after removal of the sepals (= 5½). *H.* Mature flower in longitudinal section (× 5½). *J.* Base of flower after removal of the upper sepal, seen from above (× 7). s^1, upper sepal; s^2, lateral sepal; s^3, lower sepal; p^1 lower petal; p^2 lateral petal; p^3 upper petal; *b*, spoon; *e*, entrance to the flower; *kl*, adhesive matter on the stigma; *po*, pollen; *ov*, ovary; *gr*, style; *sch*, carina with hinge (*x*).

and perhaps first becomes receptive as a result of the friction. It would seem that either the pollen of the same flower is ineffective or the foreign pollen prepotent, cross-pollination being thus ensured.

VISITORS.—Herm. Müller—in the Alps—observed 5 humble-bees, in part skg. nectar, in part getting at it by perforating the flower; also 3 Lepidoptera, skg. nectar, but useless as visitors. Dalla Torre, and also Schletterer, saw Bombus sylvarum *L.* ♀ and ☿, in the Tyrol. Hoffer (Kosmos, Stuttgart, xvi, 1885) in the Lower Alps (Steiermark) noticed the following *Apidae*.—

1. Anthophora pilipes *F.*; 2. Andrena fulva *Schr.*; 3. Apis mellifica *L.*; 4. Bombus agrorum *F.*; 5. B. hortorum *L.*; 6. B. lapidarius *L.*; 7. B. mastrucatus *Gerst.*; 8. B. pomorum *Pz.*; 9. B. pratorum *L.*; 10. B. rajellus *K.*; 11. B. sylvarum *L.*; 12. B. soroënsis *F.*; 13. B. terrester *L.*; 14. Osmia bicolor *Schr.*; 15. O. cornuta *Latr.*

Of these, Bombus mastrucatus and B. terrester steal the nectar by perforation. Apis, Bombus pratorum, and B. soroensis steal nectar through the holes made by these humble-bees.

Ricca found that 95 % of the flowers were broken, and Schulz noticed the same thing in many instances at Bozen.

370. **P. serpyllacea** Weihe (=P. depressa *Wender.*).—

Visitors.—MacLeod observed Bombus agrorum and B. hortorum in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 246).

371. **P. alpestris** Reichb. (Herm. Müller, 'Alpenblumen,' p. 168–9.)—The flower mechanism of this species agrees pretty well with that of P. comosa, but owing to the fusion of the three lower petals, there is also a certain resemblance to that of P. Chamaebuxus.

Visitors.— Herm. Müller saw only 4 sp. of butterflies in the Alps.

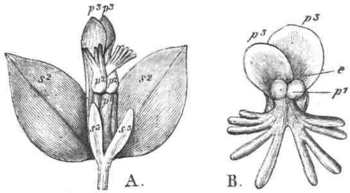

Fig. 43. *Polygala alpestris, Reichb.* (after Herm. Müller). *A.* Flower seen from below (× 7). *B.* The same, seen from the front, more highly magnified. *e*, entrance to the flower.

372. **P. myrtifolia** L.— Delpino ('Ult. oss.,' pp. 185–7) states that the flower mechanism agrees with those of certain Papilionaceae (Lathyrus, Phaseolus).

Visitors.—The same bee—Xylocopa violacea *L.*—which pollinates Lathyrus and Phaseolus does the same for this species, and in the same manner.

XV. ORDER *CARYOPHYLLEAE.*

1. Tribe Sileneae DC.

Literature.—Knuth, Grundriss d. Blütenbiologie, pp. 29–30.

The flowers are frequently large and brightly coloured, and are rendered more conspicuous by the fact that the inflorescence is often much branched. In the individual flower, the petals—which are usually long-clawed—are so held together by the gamosepalous calyx as to form a more or less elongated tube, the length of which is often increased by the presence of a corona. The nectar secreted in the base of the flower, or the juices there obtainable by boring, are therefore usually only accessible to long-tongued insects. It follows that many Sileneae are Lepidopterid flowers, the red-flowered species being butterfly flowers, and the white-flowered ones moth flowers or hawk-moth flowers.

Some species, however—Tunica prolifera, Gypsophila—possess so short and wide a tube that the nectar is accessible even to beetles and short-tongued flies. One species (Silene Otites *Sm.*) is mainly anemophilous. Of the ten stamens usually present the five outer ones almost always mature first, and the five inner ones last. Many species are conspicuously protandrous, the stigmatic papillae only developing after the stamens have withered. Homogamy is rare (Tunica prolifera). A few vary from protandry to homogamy. Certain species show different relations in different regions. In addition to the hermaphrodite flowers, many species possess some that are purely female, or may exhibit dioecism—the female flowers being usually a little smaller than the male ones, and these again inferior in size to the hermaphrodite flowers. In hermaphrodite flowers individual stamens are occasionally absent. Many species are gynodioecious (gd.), gynomonoecious (gm.), androdioecious (ad.), or andromonoecious (am.), e. g.:—

Gypsophila repens *L.*: gd., more rarely gm. (Ludwig);
G. fastigiata *L.*: gd. and gm. (Schulz);
Tunica saxifraga *Scop.*: gd. (Breitenbach), rarely gm.;
T. prolifera *Scop.*: gd. and gm. (Schulz);
Dianthus Seguierii *Vill.*: gd., rarely gm. (Schulz);
D. caesius *Sm.*: gd. (Kirchner);
D. deltoides *L.*: gd. (Schulz);
D. Armeria *L.*: gd. and gm. (Kirchner);
D. Carthusianorum *L.*: gd., rarely gm. (Schulz);
D. atrorubens *All.*, D. superbus *L.*, D. monspessulanus *L.*, D. sylvestris *Wulf.*: ditto;
Saponaria officinalis *L.*: gd., rarely gm. (Schulz);
S. ocymoides *L.*: gd. and gm., rarely ad. and am., also trimonoecious (Hildebrand);
Vaccaria parviflora *Moench*: gd., rarely gm. (Schulz);
Cucubalus baccifer *L.*: gd. and gm. (Schulz);
Silene Armeria *L.*: gd. (Breitenbach);
S. nutans *L.*: gm., gd., am., ad. (Schulz);
S. Otites *Sm.*: dioecious, rarely ad. (Knuth);
S. inflata *Sm.*: gm., gd., am., ad. (Schulz, Magnus, Knuth, and others);
S. Saxifraga *L.*: am. and gm. (Lalanne);
S. noctiflora *L.*: gm. (MacLeod), gd. and am. (Schulz);
S. dichotoma *Ehrh.*: gd. (Warming, Kirchner);
Viscaria vulgaris *Roehl.*: gm., gd., rarely ad. and am. (Schulz);
Coronaria Flos-cuculi *A. Br.*: gd., gm., rarely ad. and am. (Schulz);
C. tomentosa *A. Br.*: gd., rarely gm. (Schulz);
Melandrium rubrum *Garcke*: trioecious, rarely gm. or am. (Schulz);
M. album *Garcke*: dioecious.

115. Gypsophila L.

Flowers protandrous, usually with concealed nectar secreted by a fleshy ring formed by the thickened bases of the filaments.

373. G. paniculata L. (Herm. Müller, 'Fertilisation,' pp. 127–8, 'Weit. Beob.,' II, p. 230.)—Numerous blossoms are borne on the same stock, so that, in spite

of their diminutive size, the plant is very conspicuous. The cup-shaped flower is only 4–5 mm. in diameter, and $2\frac{1}{2}$ mm. deep. Nectar is secreted at the bottom of the cup by a green fleshy ring, and is readily accessible even to very short-tongued insects. The anthers of the five stamens which alternate with the petals mature before those of the stamens opposite the petals. They project from the flower—at the same time inclining towards the petals—and dust insect visitors with pollen. When they wither the stamens curve outwards and downwards, while the styles—at first bent inwards—now elongate and diverge from one another, projecting from the flower, so as to be pollinated by the numerous visitors that hasten from blossom to blossom.

VISITORS.—Hermann Müller observed the following.—

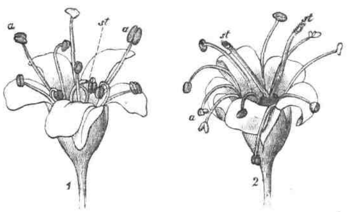

FIG. 44. *Gypsophila paniculata*, *L.* (after Herm. Müller). (1) *Flower in the first (male) condition.* (2) *Flower in the second (female) condition.* *a*, anthers; *st*, stigma.

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Lucilia sylvarum *Mg.*, skg.; 3. Miltogramma sp., skg.; 4. Mosillus arcuatus *Latr.*, skg.; 5. Onesia floralis *R.-D.*, skg.; 6. Pyrellia cadaverina *L.*, skg.; 7. Sarcophaga carnaria *L.*, skg. (*b*) *Syrphidae*: 8. Ascia podagrica *F.*, skg. and po-dvg.; 9. Eristalis aeneus *Scop.*, do.; 10. E. arbustorum *L.*, do.; 11. E. nemorum *L.*, do.; 12. Melithreptus pictus *Mg.*, do.; 13. M. taeniatus *Mg.*, do.; 14. Syritta pipiens *L.*, freq., do.; 15. Syrphus balteatus *Deg.*, do. (*c*) *Tabanidae*: 16. Chrysops caecutiens *L.*, skg. **B. Hymenoptera.** (*a*) *Apidae*: 17. Prosopis armillata *Nyl.* ♀ and ♂, skg.; 18. P. brevicornis *Nyl.* ♂, skg.; 19. P. communis *Nyl.* ♀, skg.; 20. Sphecodes ephippium *L.* ♂. (*b*) *Evaniidae*: 21. Gasteruption jaculator *F.*, skg. (*c*) *Formicidae*: several sp. (*d*) *Sphegidae*: 22. Oxybelus quattuordecimnotatus *Jur.* ♀ and ♂, skg.; 23. O. uniglumis *L.*, skg. (*e*) *Vespidae*: 24. Odynerus parietum *L.*, skg.; 25. O. quadrifasciatus *F.*, skg.

374. G. muralis L.—The flowers are flesh-coloured, and traversed by red veins; their diameter is about 5 mm. Kirchner ('Flora v. Stuttgart,' p. 242) states that the anthers of the five outer stamens mature before those of the five inner ones; the filaments elongating so that the anthers project beyond the opening of the flower.

After the pollen is shed, the filaments curve so far outwards that the styles—which now diverge and project out of the flower—cannot come into contact with the anthers, automatic self-pollination being thus prevented. In this second (female) condition the petals—which so far have been flat—roll themselves up longitudinally to some extent, so that the flowers are less conspicuous than in the first (male) condition, when they are consequently more noticed and visited by insects.

375. G. fastigiata L.—Schulz ('Beiträge,' II, p. 180) observed at Kyffhäuser gynomonoecious and gynodioecious plants, in addition to those bearing protandrous flowers. Warnstorf describes the pollen-grains as white, roundish-polyhedral, delicately papillated, 30–37 μ in diameter (Verh. bot. Ver., Berlin, xxxvii, 1895).

VISITORS.—Loew observed a bee, Prosopis communis *Nyl.*, skg., in the Berlin Botanic Garden.

376. G. repens L. (Herm. Müller, 'Fertilisation,' p. 128, 'Alpenblumen,' pp. 191–2; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 511; Ludwig, Bot. Centralbl., Cassel, xxxvi, 1888; Schulz, 'Beiträge,' II, pp. 19–20.)—The rose-red flowers vary from slight to marked protandry. Their diameter is scarcely 10 mm., but as the plant forms great plots on the stony declivities of the Alps it is very conspicuous. Nectar is secreted in great abundance. In good weather the visits of insects are, therefore, numerous, so that crossing takes place. Should insect-visits fail, automatic self-pollination obtains in the more unfavourable places. Ludwig observed cases of gynodioecism, and more rarely of gynomonoecism.

VISITORS.—Herm. Müller—in the Alps—observed chiefly flies (14 species), humble-bees (2), and Lepidoptera (5). A. Schulz noticed a similar set of visitors in the Tyrol, i. e. flies, bees, and Lepidoptera, as well as a few beetles.

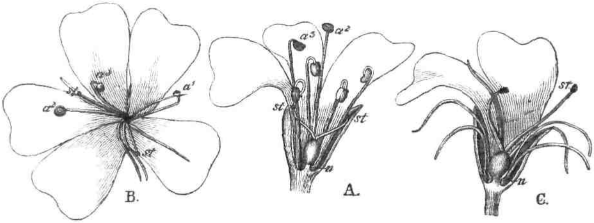

FIG. 45. *Gypsophila repens, L.* (after Herm. Müller). *A.* Flower at the beginning of the first (male) condition. *B.* Flower at the end of this condition. *C.* Flower in the second (female) condition. *a*, anthers; *st*, stigma; *n*, nectary.

MacLeod saw a bee and 13 flies in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 375–6).

377. G. perfoliata L.—

VISITORS.—Loew observed the following Syrphids in the Berlin Botanic Garden:—1. Eristalis nemorum *L.*; 2. Syritta pipiens *L.*

378. G. elegans Bilb.—This species is protandrous and self-fertile (Comes, 'Stud. s. impoll. in alc. piante').

116. Tunica Scop.

Flowers protandrous or homogamous, with concealed nectar: sometimes gynodioecious, rarely gynomonoecious.

379. T. Saxifraga Scop.—Schulz ('Beiträge,' II, pp. 20–1) states that the hermaphrodite flowers vary greatly in size: their diameter from 6–10 mm., and their depth from 4–5½ mm. The five outer stamens first mature, then the five inner ones, and lastly the stigma, at so late a stage that self-pollination is almost completely prevented. As already mentioned by Breitenbach (Kosmos, Stuttgart, xiv,

1884), there are purely female flowers in addition to the hermaphrodite ones. In the Botanic Gardens of both Marburg and Göttingen the size of these is very variable. Nectar is very abundantly secreted.

VISITORS.—Schulz—at Bozen—observed numerous flies (30 species), some of the smaller bees (about the same number of species) and Lepidoptera, and also some beetles.

Loew noticed the bee Halictus minutissimus K. ♂, *skg., in the Berlin Botanic* Garden, and Schletterer saw the following bees at Pola:—1. Andrena nana *K.*; 2. A. parvula *K.*; 3. Halictus morio *F.*

380. T. prolifera (=Dianthus prolifer *L.*). (Schulz, 'Beiträge,' II, p. 21; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 213, 298.)—This plant also—according to Schulz—is gynodioecious and gynomonoecious. The flowers are homogamous—at Halle and Bozen—so that automatic self-pollination regularly takes place. This only is of importance, for the small inconspicuous flowers produce but little nectar and have few insect visitors—some nectar-sucking butterflies and pollen-devouring flies. Further, according to Kerner, the anthesis lasts but two days, and the flowers are only open from 8 a.m. till 1 p.m.

VISITORS.—Vide supra.

117. Dianthus L.

The protandrous flowers are usually large, and often beautifully coloured. The claws of the petals are long and winged. They are held together—so as to form a long tube—by the calyx, which is usually surrounded by tough granular

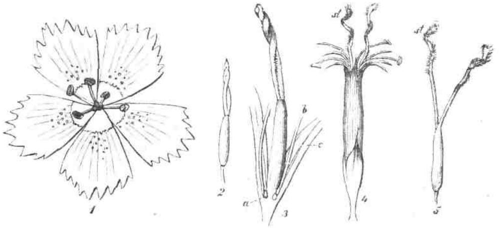

FIG. 46. *Dianthus deltoides, L.* (after Herm. Müller). (1) Flower in the first (male) condition, seen from above. Five anthers covered with pollen protrude from the flowers; two that have not yet dehisced are visible in the mouth of the tube. (2) Pistil at the end of the first stage. All the anthers have dehisced, and the two styles are still twisted together. (3) The same, with the bases of stamens and petals (more highly magnified): *a*, nectary; *c*, petals; *b*, filaments. (4) Flower in the second (female) condition after removal of the petals, seen from the side. Most of the anthers have fallen off, and the styles have separated. (5) Pistil of the same flower. The separated styles retain their spiral form, so that stigmatic papillae are turned towards all sides.

bracts, serving as a protection against the bites of humble-bees trying to break in laterally. Nectar is secreted and concealed at the bottom of the corolla-tube, which is usually so long and narrow that it is accessible only to Lepidoptera, some-

times even to only such of these as possess a very long proboscis (hawk-moths). The flowers therefore belong to class **L.** Many species are gynomonoecious or gynodioecious.

381. **D. deltoides** L. (Herm. Müller, 'Fertilisation,' pp. 125–6, 'Weit. Beob.,' II, p. 230; Kirchner, 'Flora v. Stuttgart,' p. 244; Knuth, 'Bloemenbiol. Bijdragen.')—*This species bears protandrous butterfly flowers.* Hermann Müller (op. cit., p. 125) says that—'The stamens and petals spring from an annular ridge of the receptacle encircling the stalk of the ovary. This ridge bears on its inner border a yellow fleshy cushion which secretes honey.' As the calyx tube is 12–14 mm. long, the passage to the nectar is of the same length, while it is only 2 mm. in diameter. At the beginning of anthesis this passage is made so narrow by the five inner stamens it encloses as to leave only enough room for the introduction of a butterfly's proboscis. The path to the nectar is indicated by a nectar-guide on the rose-red corolla, of which the whitish centre is surrounded by a purple-red ring with whitish spots. Of the ten stamens, the five outer ones first elongate so that their anthers project from the corolla-tube when they have dehisced. After the outer stamens have withered the other five behave similarly. When all the pollen is shed the two styles—which have so far been twisted together within the corolla-tube—elongate, and their stigma-bearing ends project from the flower, dominating its entrance. When the styles separate they remain spirally twisted, so that the proboscis of a butterfly approaching the flower from any side must necessarily touch some of the stigmatic papillae, effecting cross-pollination if the insect has previously visited a younger flower.

VISITORS.—The following were observed by Herm. Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein.—

Lepidoptera. (*a*) *Bombycidae*: 1. Gnophria quadra *L.*, skg. (?) (H. M.). (*b*) *Tineidae*: 2. Nemotois metallicus *Poda* (H. M.). (*c*) *Rhopalocera*: 3. Hesperia lineola *O.*, very freq., skg. (H. M.); 4. H. thaumas *Hfn.*, skg. (H. M.); 5. Lycaena icarus *Rott.*, skg. (Kn., H. M.); 6. Pieris napi *L.*, skg. (H. M.); 7. P. rapae *L.*, skg. (H. M.); 8. P. sp., skg. (H. M.); 9. Polyommatus phlaeas *L.* skg. (Kn.); 10. Rhodocera rhamni *L.*, skg. (Kn.); 11. Epinephele janira *L.* (H. M.).

I saw in Thuringia, as a useless visitor, the small bee Halictus morio *F.* ♀, vainly trying to suck nectar, and afterwards po-cltg.

Loew noticed the following in Silesia (' Beiträge,' p. 35).—

A. Diptera. *Syrphidae*: 1. Volucella bombylans *L.*, trying to suck. **B. Lepidoptera.** *Rhopalocera*: 2. Argynnis pandora *S. V.*, skg.; 3. Pieris brassicae *L.*; 4. Rhodocera rhamni *L.*, skg.

382. **D. superbus** L. (Sprengel, 'Entd. Geh.,' p. 248; Herm. Müller, 'Fertilisation,' p. 127, 'Alpenblumen,' pp. 202–4.)—The fragrant protandrous diurnal *hawk-moth flowers are red in colour, and elegant in appearance, owing to the* delicately dissected petals. Their mechanism agrees with that of the last species, though the nectar is so deeply concealed (20–25 mm.), and the access to it so narrow, that even butterflies cannot reach it, but only the diurnal hawk-moths (species of Macroglossa). Self-pollination is excluded. Besides hermaphrodite flowers, infrequent female ones have been observed, which are smaller than the

others. Schulz states that the large-flowered variety *grandiflora* Tausch, which occurs in the Riesengebirge, also possesses much smaller female flowers.

Warnstorf (Ver. bot. Ver., Berlin, xxxviii, 1896) was able to distinguish the following varieties at Ruppin.—

1. Large-flowered variety. Diameter of corolla about 6 cm.; all the filaments developed, but a larger or smaller number of the anthers brown and vestigial.

2. Medium-flowered variety. Diameter of corolla about 4 cm.; all the stamens fully developed, so that the flowers are all hermaphrodite. A few medium-sized hermaphrodite flowers are often found on the first variety.

Both these varieties are markedly protandrous. The stamens develop gradually, ultimately projecting far out of the calyx-tube, which is about 23–25 mm. long. The whitish anthers are introrse; after dehiscence they bend back through an angle of 90°, so that the anther-lobes—which spread out so as to be almost flat—lie at right angles to the filaments. The pollen-grains are white, dodecahedral, tuberculated, and with an average diameter of 50 μ.

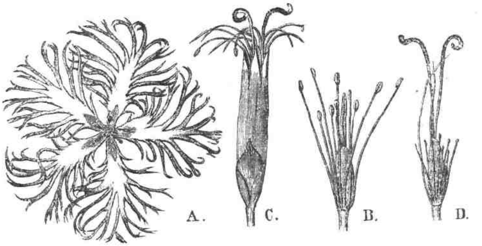

FIG. 47. *Dianthus superbus, L.* (after Herm. Müller). *A.* Hermaphrodite flower in the first (male) condition, seen directly from above (natural size). *B.* Stamens and pistil in the same condition, seen from the side. *C.* A similar flower in the second (female) condition ($\times$ 2). *D.* Sexual organs of a purely female flower. Eight of the stamens possess minute vestigial anthers, and are only as long as the ovary. The other two stamens are devoid of anthers, and twice as long.

3. Small-flowered variety. Diameter of corolla only about 3 cm.; all the stamens reduced to small vestiges at the base of the calyx-tube, so that the flowers are female. These female plants are rare at Ruppin.

The dissected blade of the petals of all the varieties is either from light to dark violet in colour, or else pure white. In the former case, the patch at the base of the blade is dirty-green, and beset with long purple hairs, while the rest of the blade is covered with very short violet hairs: in the latter case the basal patch is of a beautiful bright green, and covered with colourless hyalineh airs, as also is the rest of the blade. It is also remarkable that these white-flowered plants are distinguishable, even at a distance, from dark-flowered specimens growing near them, by the pale-green colour of stem, branches, leaves, and calyx (Warnstorf).

383. **D. Armeria** L. (Kirchner, 'Flora v. Stuttgart,' p. 245; Schulz, 'Beiträge,' III, p. 21.)—Kirchner says that though the flowers essentially agree with those of D. deltoides, yet—in accordance with their inconspicuousness—automatic self-pollina-

tion is possible, the styles being developed before the outer anthers have lost all their pollen. The corolla is bright red with clearer spots; its diameter is 13 mm., its tube 15 mm. long, and scarcely 2 mm. wide. Besides the hermaphrodite flowers there are some in which one staminal whorl is vestigial, and others again that are purely female, the yellow anthers remaining enclosed in the corolla-tube, and not dehiscing. *The plant is therefore gynodioecious and gynomonoecious.*

VISITORS.—*According to the observations of A. Schulz, these are very infrequent*: he only saw one butterfly (Vanessa urticae).

384. **D. Carthusianorum** L. (Sprengel, 'Entd. Geh.,' pp. 250–1; Herm. Müller, 'Fertilisation,' pp. 126–7, 'Weit. Beob.,' II, p. 230; Schulz, 'Beiträge,' I, p. 5; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 36–7, 'Bloemenbiol. Bijdragen.')—The mechanism of the protandrous diurnal hawk-moth flowers agrees with that of D. deltoides. There are female flowers in addition to the hermaphrodite ones. The plant is gynodioecious, more rarely gynomonoecious.

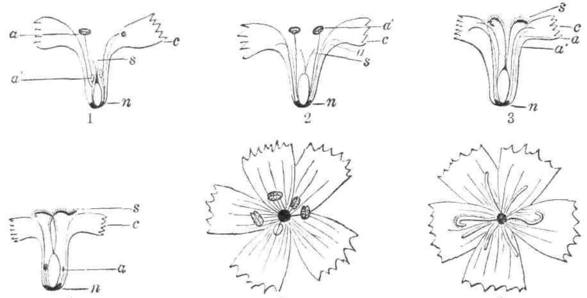

FIG. 48. *Dianthus Carthusianorum, L.* (Natural size, after removal of calyx and three of the petals. From nature, semi-diagrammatic.) (1) *a*, two stamens of the outer whorl, one with pollen, the other dehisced and empty; *a*[1], two stamens of different lengths belonging to the inner whorl; *s*, stigma (undeveloped); *c*, two petals; *n*, nectaries. (2) *a*, two withered stamens of the outer whorl: *a*[1], two mature stamens of the inner whorl; *s*, *c*, *n*, as in (1). (3) *a*, *a*[1], withered stamens of the outer and inner whorls respectively; *s*, mature stigmas; *c*, *n*, as in (1). (4) Variety with vestigial stamens. (5) Flower in the first (male) condition, seen from above. (6) Flower in the second (female) condition, seen from above.

Warnstorf (Verh. bot. Ver.. Berlin, xxxvii, 1895) found both large and small flowers at Ruppin. The former are androdynamous-protandrous. At the time when the pollen is mature the lilac anthers project far beyond the style. Pollen-grains large, rounded, covered with a delicate net-work of tubercules, 44–50 μ in diameter. The small flowers are imperfectly hermaphrodite. At the time when the stigma is mature the stamens are much shorter than the style. The yellowish anthers are smaller; their pollen-grains are polyhedral and papillose, with a maximum diameter of 31 μ.

VISITORS.—*On the North Frisian Islands I saw Lepidoptera, and—as unbidden guests—small bees, as well as various flies, beetles, and grasshoppers.*

Hermann Müller (H. M.) and myself (Kn.) observed the following in Central Germany.—

Lepidoptera. (*a*) *Noctuidae*: 1. Plusia gamma *L.* (Kn., H. M.), freq., skg. (*b*) *Rhopalocera*: 2. Coenonympha arcania *L.* (H. M.), skg.; 3. Colias hyale *L.* (Kn.); 4. Hesperia sp. (H. M.), repeatedly; 5. H. lineola *O.* (H. M.), very freq., skg.; 6. H. silvanus *Esp.* (H. M.), do.; 7. Melanargia galathea *L.* (H. M.), skg.; 8. Polyommatus phlaeas *L.* (Kn., M. H.); 9. Rhodocera rhamni *L.* (Kn., H. M.), freq.; 10. Syrichthus malvae *L.* (H. M.), freq., skg. (*c*) *Sphingidae*: 11. Macroglossa stellatarum *L.* (H. M.); 12. Zygaena carniolica *Scop.* (H. M.); 13. Z. lonicerae *Esp.* (H. M.), skg. freq.; 14. Z. pilosellae *Esp.* (Kn., H. M.), do.; 15. Z. trifolii *Esp.* (Kn.), do. All skg.

As useless visitors Herm. Müller also observed the following beetles:—Oedemera podagrarieae *L.*; Danacea pallipes *Pz.*; and Spermophagus cardui *Stev.*: and Rossler—at Wiesbaden—saw 2 Lepidoptera, nect-skg., i. e. Ino geryon *Hüb.*, and Dianthoecia compta *F.*

385. **D. chinensis** L.—This species bears protandrous Lepidopterid flowers.

Visitors.—Herm. Müller saw moths—Plusia gamma *L.*, Agrotis pronuba *L.*, Brotolomia meticulosa *L.*—on the flowers in his garden.

386. **D. barbatus** L.—This species bears protandrous diurnal Lepidopterid flowers (Sprengel, 'Entd. Geh.,' p. 251).

Visitors.—I observed Macroglossa stellatarum *L.* in the gardens of Föhr and Helgoland, and in the latter some butterflies—Pieris brassicae *L.*, Vanessa urticae *L.*—as well. All skg.

387. **D. sylvestris** Wulf. (Herm. Müller, 'Fertilisation,' p. 127, 'Alpenblumen,' pp. 204–5; Schulz, 'Beiträge,' II, pp. 22–3.)—This species possesses protandrous diurnal Lepidopterid flowers. They are fragrant and rose-coloured, and expand into a disk 25–35 mm. in diameter. The nectar is so deep—according to Schulz as much as 18–25 mm.—that it is as much as diurnal Lepidoptera can do to reach it, and Müller says that a proboscis 18–20 mm. long is required. Otherwise the mechanism of the flower agrees with that of D. deltoides, the other species already described. According to Schulz, the plant is sometimes gynodioecious, more rarely gynomonoecious.

Visitors.—Macroglossa stellatarum *L.* has been observed by Müller in the Suldenthal, and by Schulz at Bozen.

388. **D. atrorubens** All.—This species bears protandrous diurnal Lepidopterid flowers, of which the dark-red petals are covered with darker hairs and marked with darker spots. The nectar is deeply seated—13–15 mm. according to Müller, 10–17 mm. according to Schulz—and is accessible to many diurnal Lepidoptera. Besides fully-developed protandrous hermaphrodite flowers, Schulz observed some female ones, distributed gynodioeciously, more rarely gynomonoeciously.

Visitors.—Herm. Müller observed butterflies—4 species, skg.—in the Alps, and also Zygaena minos *W. V.* (=Z. pilosellae *Esp.*), vainly trying to reach the nectar. A. Schulz ('Beiträge,' II, p. 22) saw 2 species of Lepidoptera at Bozen in the Tyrol.

389. **D. arenarius** L.—This species bears protandrous nocturnal hawk-moth flowers (?), the mechanism of which has been described by Kirchner ('Beiträge,'

p. 18) from garden specimens. The calyx is 16 mm. in length, and only $2\frac{1}{2}$–3 mm. wide. It closely ensheaths the claws of the white petals, which project about 9 mm. beyond it. The stamens and carpels develop in the usual order.

VISITORS.—The deeply seated nectar, and the white colour of the corolla, suggest that the flowers are pollinated by nocturnal hawk-moths.

390. **D. monspessulanus** L.—According to Schulz ('Beiträge,' II, p. 23) the nectar is placed at a depth of 14–25 mm. in the flesh-coloured or white Lepidopterid flowers, of which the diameter varies between 25 and 35 mm. The order of development of stamens and carpels is the same as in other species. Near Bozen Schulz also observed female flowers, with a minimum diameter of 8 mm.

VISITORS.—Macroglossa stellatarum *L.*, which possesses a proboscis 25–28 mm. long, that can easily reach all the nectar, was observed by A. Schulz at Bozen, and also by G. E. Mattei ('I lepidotteri e la dicogamia,' 1888, p. 16). MacLeod (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 377) did not see any normal visitors in the Pyrenees, but only a flower-beetle.

391. **D. Caryophyllus** L.—According to Darwin, this species is self-sterile.

392. **D. neglectus** Loisel.—Kerner says that the flowers of this species are protandrous, though later on automatic self-pollination is possible. The flowers are open in the morning, and between 6 and 7 o'clock in the evening.

393. **D. glacialis** L.—According to Kerner, the flowers are at first protandrous, but automatic self-pollination may afterwards take place. The plant is also gynodioecious.

394. **D. caesius** Sm.—Kirchner ('Beiträge,' pp. 17–18) states that the mechanism of the rose-coloured flowers—which smell strongly of cloves—agrees with that of D. sylvestris. Besides the protandrous hermaphrodite flowers, some stocks—at Uberlingen—also bear female flowers of the same size.

395. **D. Seguierii** Vill.—Besides the protandrous hermaphrodite flowers, Schulz observed female ones, which were either borne on the same plants as the former or on different ones.

396. **D. plumarius** L. (Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 231.)—

VISITORS.—I observed Bombus hortorum *L.*, skg., in the gardens on the island of Föhr.

118. Saponaria L.

Markedly protandrous Lepidopterid flowers. The petals narrow abruptly into long-winged claws. The somewhat ventricose calyx—which is not surrounded by bracts—holds these together to form a long tube in which the nectar is concealed, and which is prolonged upwards by a corona consisting of bifid ligules. There may be gynomonoecism and gynodioecism.

397. **S. officinalis** L. (Sprengel, 'Entd. Geh.,' p. 248; Herm. Müller, 'Fertilisation,' pp. 128–9, 'Weit. Beob.,' II, p. 232; MacLeod, 'Pyreneenbl.,' p. 101, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 151–3; Kirchner, 'Flora v. Stuttgart,' p. 246; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 37–8, 151; Schulz, 'Beiträge,'

I, p. 6.)—The white or flesh-coloured petals of the protandrous hawk-moth flowers are devoid of nectar-guides. A fragrant odour is exhaled, becoming much stronger in the evening. Nectar is secreted and concealed at the bottom of the calyx-tube—which is 18–21 mm. in length, and is prolonged a few mm. by the corona—and can only be reached by Lepidoptera possessing a very long proboscis. The five outer stamens first project from the flower, above the entrance to which their anthers dehisce. After shedding their pollen they diverge, leaving the entrance of the flower free for the inner whorl of stamens. When these have shed their pollen the two styles grow up, spreading out their stigmas at the level previously occupied by the anthers. Self-pollination is therefore excluded. The species is sometimes gynodioecious, more rarely gynomonoecious.

VISITORS.—These are chiefly hawk-moths (Sphinx and Macroglossa). Hermann Müller saw Sphinx ligustri *L.*, skg.; I myself noticed Macroglossa stellatarum *L.* in the Kiel Botanic Garden. MacLeod very frequently saw this species in the Pyrenees; also Sphinx convolvuli *L.*, of which a single individual visited twenty-nine flowers in two minutes. Kerner observed Noctuidae belonging to the genera Dianthoecia and Mamestra. Owing to the shortness of their proboscis, butterflies cannot secure the nectar: I observed, for example, Vanessa io *L.* vainly trying to suck the flower in the North Frisian islands. Nor was the honey-bee able to reach the nectar. I also noticed there po-dvg. hover-flies and Lucilia caesar *L.* Buddeberg found a small bee—Halictus morio *F.* ♀—po-cltg. on the flowers as an unbidden guest.

In the Netherlands, H. de Vries (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875) observed a humble-bee—Bombus terrester *L.* ♀—probably only po-cltg.

398. S. ocymoides L.—This species bears protandrous Lepidopterid flowers. *Hermann Müller ('Alpenblumen,' pp. 200–1) states that the stamens and carpels* develop in the same order as among the Sileneae already described, and that automatic self-pollination is exceptionally possible as a last resort. A divergent feature is that each of the five outer stamens expands at its base into a fleshy red appendage, which probably secretes the nectar. Besides protandrous hermaphrodite flowers, there are also purely female ones, and in rare instances purely male ones as well. The plant, according to Hildebrand ('Die Geschlechtsvert. b. d. Pfl.,' p. 11), is gynodioecious, gynomonoecious, androdioecious, andromonoecious, or even trimonoecious (☿=♂>♀).

VISITORS.—Herm. Müller observed numerous Lepidoptera (more than 30 species) in the Alps; also some humble-bees (3 species) and Bombyliidae (2 species), which reached the honey only with difficulty. A. Schulz ('Beiträge,' II, pp. 24–6) also noted a preponderance of Lepidoptera (35 species) in the South Tyrol, together with a few humble-bees nect. skg., and po-dvg. flies. This observer very frequently found the flowers of which the calyx had been perforated and the nectar stolen by Bombus mastrucatus *Gerst.*, or more rarely by B. terrester *L.*

119. Vaccaria Medicus.

Protandrous, homogamous, or feebly protogynous Lepidopterid flowers. Calyx ventricose—as a protection against humble-bees—acutely pentagonal, almost winged, and devoid of basal bracts; petals with winged claws; no corona. Sometimes gynomonoecious and gynodioecious.

399. **V. parviflora** Moench (= S. Vaccaria *L.*). (Herm. Müller, 'Weit. Beob.,' II, pp. 231–2; Schulz, 'Beiträge,' II, pp. 23–4; Kirchner, 'Flora v. Stuttgart,' p. 247.)—This species bears butterfly flowers. Herm. Müller says that the expansion of the calyx is so great that its diameter below the middle may be as much as 7 mm. Its ventricose surface is deeply enfolded between the sharp projecting longitudinal ribs. The protection against robbery by humble-bees—e. g. Bombus terrester—is thus rendered more effective, as the bees cannot perforate the folds, and if they bite through the edges can scarcely reach the nectar. The folds also hold together the claws of the petals, which are flesh-coloured to rose-red. The calyx-tube narrows above, so that it is almost closed by the petals, stamens, and pistil, and can only be traversed by the proboscis of a butterfly. Nectar is secreted in small quantities at the bottom of the calyx, at a depth of 15–18 mm. The flowers are sometimes slightly protogynous, not infrequently protandrous, and often homogamous. Automatic self-pollination is always possible. Kerner says that it is brought about by continued growth of the stamens. Although autogamy is indicated by the inconspicuousness of the flowers, cross-pollination by insects is ensured at the beginning of anthesis. Female flowers have been observed, in addition to the hermaphrodite ones. The plant is gynomonoecious and gynodioecious.

Visitors.—Schulz observed butterflies in eastern Westphalia, i. e. species of Pieris, especially P. brassicae *L.*

120. Cucubalus Tourn.

The ventricose companulate calyx protects the flower from humble-bees; the petals gradually narrow into the long claws.

400. **C. baccifer** L.—Schulz ('Beiträge,' II, p. 81) states that the hermaphrodite flowers of this species are protandrous. There are also a small number of female flowers on the same, or on special plants.

121. Silene L.

Protandrous, homogamous, or protogynous flowers, with nectar concealed in various ways. The calyx is tubular to ventricose, serving in the latter case as a protection against the bites of nectar-stealing humble-bees. A corona is sometimes present. The long claws of the petals are often held together so firmly by the calyx that the approach to the nectar secreted in the base of the flower is only available to Lepidoptera; many species of this genus, therefore, belong to the flower class **L.** In other species the nectar is easily accessible to long-tongued bees, and such species are placed in class **H.** There are also many flowers in which the nectar is still less deeply concealed, and these belong to class **C.** One species—S. Otites—is peculiar in being chiefly anemophilous. Gynomonoecism and gynodioecism are common.

According to Rohrbach ('Monogr. d. Gatt. Silene,' Leipzig, 1868, pp. 41–3), the following species are exclusively autogamous:—S. antirrhina *L.*, S. apetala *Willd.*, S. cerastoides *L.*, S. clandestina *Jacq.*, S. gallica *L.*, S. hirsuta *Lag.*, S. inaperta *L.*, S. longicaulis *Pourr.*, S. tridentata *Desf.*

Batalin observed cleistogamous flowers on the following species of Silene:— S. vilipensa *Kunze*, S. hirsuta *Lag.*, S. gallica *L.*, S. cerastoides *L.*, S. tridentata *Desf.*, S. clandestina *Jacq.*, S. longicaulis *Pourr.*, S. apetala *Willd.*, S. inaperta *L.*, S. antirrhina *L.*

401. **S. inflata** Sm. (=S. vulgaris *Garcke*). (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 46; Herm. Müller, 'Fertilisation,' p. 129, 'Alpenblumen,' pp. 198–9; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Kirchner, 'Flora v. Stuttgart,' p. 248; A. Schulz, 'Beiträge,' I, pp. 9–10; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 374–5, vi, 1894, p. 154; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 38–9, 151, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 231; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The species bears protandrous-trioecious Lepidopterid and humble-bee (?) flowers. The white bilobed petals possess no nectar-guides. The nectar is concealed at a depth of 10–12 mm., but the entrance to the flower is not very narrow, admitting even the proboscis of a humble-bee. The female flowers are smaller than the male and hermaphrodite ones, and the first two kinds each possess vestigial reproductive organs of the opposite sex. The hermaphrodite flowers are protandrous, and capable of self-pollination. The inflated calyx is not always an effective protection against the bites of nectar-stealing humble-bees, for Bombus terrester and B. mastrucatus sometimes—though not always, as MacLeod observed in the Pyrenees—succeed in stealing the nectar after perforating the calyx.

According to Schulz, the sexes in this species are distributed in a five-fold manner; there being hermaphrodite, male, female, gynomonoecious and andromonoecious stocks. The occurrence of these forms is very variable; in some places male plants seem to be wanting altogether, or at least to be rarer than female ones.

Visitors.—These are partly Lepidoptera (mostly moths), partly humble-bees, skg. in both cases. In the North Frisian Islands I saw 2 Lepidoptera—Plusia gamma *L.* and Epinephele janira *L.*—and a humble-bee—Bombus lapidarius *L.* Kerner observed Noctuidae—Dianthoecia and Mamestra—in the Tyrol. Loew ('Beiträge,' p. 28) noticed Bombus agrorum *F.* ☿, skg., in Lower Silesia. Rössler—at Wiesbaden—saw the moth Dianthoecia nana *Rott.*, skg. Herm. Müller observed Lepidoptera—2 moths and 3 butterflies—and 7 species of humble-bee in the Alps. MacLeod—in the Pyrenees—noticed 3 species of humble-bee, a wasp, a Bombylius (skg. while resting on the flower!), and a po-dvg. Muscid, but no Lepidoptera. Lindman saw a humble-bee, a Lepidopterid, and a fly by the Hardanger Fjord, and Warnstorf—in Brandenburg—observed numerous ants as unbidden guests.

In Dumfriesshire an Empid, and numerous Muscids and hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 23).

402. **S. nutans** L. (Sprengel, 'Entd. Geh.,' p. 252; Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Herm. Müller, 'Fertilisation,' p. 129, 'Alpenblumen,' pp. 197–8; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' I, pp. 6–7; Kirchner, 'Flora v. Stuttgart,' p. 248; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 40–1.)—The protandrous moth flowers—which smell like hyacinths at night—are of a dirty white colour, devoid of nectar-guides, and conceal their nectar at a depth of 13–14 mm. Kerner says that in the Tyrol they mature their stamens and pistil on three consecutive nights. The hermaphrodite flowers—which are the

commonest—are markedly protandrous. The anthers of the outer whorl of stamens mature during the first night, those of the inner whorl during the second night, and the stigmas during the third. Self-pollination is therefore excluded. The flowers are closed and devoid of odour during the day. Besides the hermaphrodite blossoms, male and female ones have been observed. The plant is gynomonoecious and gynodioecious, andromonoecious and androdioecious. The female blooms are smaller than the others, but a small-flowered hermaphrodite variety also occurs. The anthers project far out of the flower, and the stigmatic papillae are long, which characters Schulz regards as indications of anemophily. This investigator—working at Halle, and in Thuringia, the Tyrol and North Italy—was unable to confirm Kerner's observations except in a few points. He found, on the contrary, that the stamens and pistil may mature at any time, and that the interval between the three stages of development is not so regular as Kerner asserts. Schulz also questions the general correctness of Kerner's statement that the petals always roll up in the daytime, thus making the flowers quite inconspicuous; for on high regions (2,000–2,200 m. above sea-level) this rolling-up only occurs in very sunny spots during the middle of the day. The plants I investigated in Sylt and subsequently in the garden of the Realschule at Kiel, agreed with Kerner's account: in the daytime they looked faded, and were quite odourless; at dusk their petals became turgid, and a powerful scent of hyacinths was exhaled. Unfortunately, I did not see any guests.

Visitors.—Owlet-moths (Noctuidae) have been observed—Dianthoecia and Mamestra—which, Kerner says, lay their eggs in the flowers, and according to Buchanan White (Justs bot. Jahresber., Leipzig, 1873, p. 377), they stand in much the same relation to Silene as the Yucca-moth to Yucca (cf. Vol. I, pp. 102–3).

Rossler observed the following Lepidoptera at Wiesbaden.—1. Cidaria hydrata *Tr.*; 2. Dianthoecia albimacula *Bkh.*; 3. Cucullia chamomillae *Schiff.*

Herm. Müller—in the Alps—saw 2 butterflies and a moth, also 3 species of humble-bee, of which two obtained nectar by perforating the flowers. Loew ('Beiträge,' p. 63) observed Bombus hortorum *L.* ☿, skg., by Lake Como, and Frey saw the moth Pterogon proserpina *Pall.* Schulz noted butterflies and moths, besides humble-bees, of which some obtained nectar by perforation.

403. **S. dichotoma** Ehrh.—The white flowers are protandrous. Gynodioecism was observed by Warming in Denmark, and by Kirchner in Wurtemberg.

404. **S. Armeria** L.—MacLeod says that the rose-red flowers are distinctly protandrous, with a corolla-tube 16–18 mm. long, and nectar accessible only to Lepidoptera.

Besides the hermaphrodite flowers, Breitenbach has observed (Kosmos, Stuttgart, xiv, 1884) female ones on distinct plants in the Botanic Gardens of Marburg and Göttingen. The flowers are protected against creeping animals (ants) by the sticky nature of the upper internodes.

Visitors.—MacLeod observed diurnal hawk-moths—Macroglossa—and moths—Plusia—in Belgium.

405. **S. longiflora** Ehrh.—The white flowers smell like hyacinths at night, and open between eight and nine in the evening.

Visitors.—Kerner says that moths are the pollinating agents.

406. S. viridiflora L.—According to Kerner, the flowers exhale an odour of hyacinths at night.

Visitors.—The species appears to be moth-pollinated. Schletterer observed the bee Halictus patellatus *Mor.* at Pola.

407. S. Otites Sm. (Herm. Müller, 'Weit. Beob.,' II, p. 234; Schulz, 'Beiträge,' I, p. 78; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 39–40, 151, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 232.)—The plant is almost dioecious (entirely so in the island of Röm). The male blossoms are much more numerous than the female ones, while hermaphrodite flowers occur occasionally. The petals only project 2–3 mm. beyond the calyx—which is 4 mm. long—within which they are almost entirely concealed in female flowers from some localities. Nectar is secreted and concealed in the base of the flower. The nectaries of the male flowers are non-functional in Central Germany; those of the female flowers in the same region are not accessible to insects in the normal way, owing to the closeness of the calyx to the ovary (Schulz). In the North Frisian island of Röm, and in the Tyrol, both kinds of flower secrete nectar, which is accessible to and secured by insects. It would appear, therefore, as if the flowers were in part anemophilous, and in part entomophilous. Of the ten stamens of the male flower, only the five of the outer whorl at first mature, at the same time projecting 3–4 mm. beyond the calyx-tube. They are afterwards replaced by the five stamens of the inner whorl. In the female flower the stigma also projects a few mm. We must suppose that, even in these nectar-producing flowers, wind is the chief pollinating agent, for none of the female flowers I observed in the island of Röm remained unfertilized, in spite of the very limited number of insect visitors. This is confirmed by the great preponderance of male flowers. The hermaphrodite flowers are distinctly protandrous. The plant is usually protected against creeping insects by a sticky stem.

Visitors.—I observed 4 nectar-sucking Lepidoptera in the North Frisian Islands, i.e. Epinephele janira *L.*, Coenonympha pamphilus *L.*, Plusia gamma *L.*, and Zygaena filipendulae *L.*; and also a few Hemiptera, vainly seeking for nectar. Verhoeff saw Plusia gamma *L.*, skg., on Norderney. Herm. Müller noticed fossorial wasps—Cerceris variabilis *Schr.* ♀ and ♂, and Philanthus triangulum *F.* ♂—nect. skg., at Kitzingen.

408. S. gallica L.—

Visitors.—Buddeberg observed a small po-cltg. bee, Halictus smeathmanellus *K.* ♀ (Herm. Müller, 'Weit. Beob.,' II, p. 235).

409. S. Saxifraga L. (= S. petraea *Waldst. et Kit.*).—Lalanne (Justs bot. Jahresber., Leipzig, xvi, 1888, p. 563) states that sometimes the ovaries, sometimes the anthers are vestigial. Kerner describes the plant as trioecious, with strongly protandrous hermaphrodite flowers, that only open in the evening between eight and nine o'clock.

Visitors.—These are apparently moths.

410. S. rupestris L. (Herm. Müller, 'Alpenblumen,' pp. 193–4; Schulz, 'Beiträge,' II, pp. 29–30.)—The hermaphrodite flowers are protandrous, but the

possibility of automatic self-pollination is apparently not precluded. Plants observed by Warming in the Scandinavian highlands were also strongly protandrous, as were those examined by Schulz in the Tyrol. The latter describes the plant as gynodioecious, rarely gynomonoecious, very rarely androdioecious or andromonoecious.

VISITORS.—Loew observed the following in Switzerland ('Beiträge,' p. 60).—

Diptera. *Bombyliidae*: 1. Argyromoeba sinuata *Fall.*; 2. Bombylius minor *L.*

Herm. Müller—in the same country—saw numerous Lepidoptera, especially Noctuidae, and flies; also some bees.

A. Schulz observed a similar circle of guests in the Tyrol.

MacLeod noticed a Muscid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1591, p. 375).

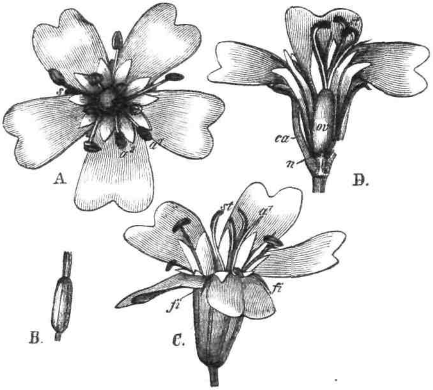

FIG. 49. *Silene rupestris, L.* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Pistil of the same flower with the branches of the style still closely apposed, and stigmas not yet mature. *C.* Flower in the second (hermaphrodite) stage. *D.* Flower in the third (female) stage.

411. **S. acaulis** L. (Herm. Müller, 'Fertilisation,' p. 129, 'Alpenblumen,' pp. 194–7; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 375–6; Ricca, Atti Soc. ital. sc. nat., Milano, xiii, 1870.)—This species is trioecious. The markedly protandrous hermaphrodite red flowers are crowded together in great numbers, and are visited by so many insects that there is scarcely any or no necessity for automatic self-pollination. In some places, however, none of the flowers are bisexual (Schulz, Warming). Ekstam says that in dioecious plants in Nova Zemlia the diameter of red or white corolla is 6–12 mm. The only unisexual flowers there observed were male; the bisexual ones were—as elsewhere—protandrous.

According to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora'), this species flowers in Spitzbergen from the beginning of July to the end of August; during the latter month fruits are regularly ripened.

The colour of the corolla varies from pure white—as in males infested by Ustilago violacea—to bright violet and red violet. In Spitzbergen—as in Greenland—there are male and female flowers as well as hermaphrodite ones. On a clump of the plant containing the remains of several hundred female flowers of the preceding year, the above-named investigators only found two ripe seed-containing fruits. In their opinion the fact indicated the ineffectiveness of cross-pollination in Spitzbergen. The clumps of Silene acaulis often show very beautifully the effect of direct isolation on anthesis, for the southern half—exposed to the sun—presents a dense mass of expanded flowers while the northern half remains more or less in bud.

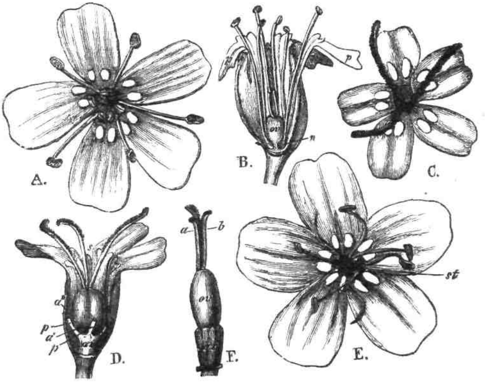

FIG. 50. *Silene acaulis, L.* (after Herm. Müller). *A.* Flower half-way through the first (male) condition. *B.* Smaller male flower at the end of anthesis. *C.* Female flower, seen from above. *D.* The same in section. *E.* Hermaphrodite flower at the end of the male stage. *F.* Pistil of the same flower.

VISITORS.—Herm. Müller observed—in the Alps—numerous Lepidoptera—28 Macro-lepidoptera, and 4 Micro-lepidoptera—as well as some bees, Muscidae, Syrphidae, and anther-eating beetles.

Frey—in the same region—saw the moth Anarta melanopa *Thunb.*, and in Switzerland the species Anarta nigrita *Bsd.* MacLeod observed 6 Lepidoptera, and 3 pollen-eating beetles in the Pyrenees. Lindman noticed a humble-bee on the Dovrefjeld, as did Ekstam in Nova Zemlia. Schneider (Tromsø Mus. Aarsh., 1894) saw Bombus agrorum *L.* and B. lapponicus *L.* in Arctic Norway. For Spitzbergen, Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 24) records two cases of visits by small Dipterids, and one by a spider (!), which was doubtless hunting flies.

412. S. noctiflora L. (= Melandrium noctiflorum *Fries*).—**The hermaphrodite flowers are fragrant when they open in the evening, between seven and eight o'clock, according to Kerner, though Warnstorf has seen them open as early as between five**

and six p.m. MacLeod states that the protandry is so marked that self-pollination is excluded. The nectar is concealed at a depth of 18 mm.

In Belgium the plant is gynomonoecious (MacLeod); Warnstorf observed gynodioecism at Ruppin; and Schulz says that this is the most frequent condition, but that in some places androdioecism and andromonoecism may occur. Schulz now and then observed flowers which had been perforated by bees. The female flowers—which were long since observed by Gärtner—are only 12 mm. deep. According to Hansgirg, pseudo-cleistogamous flowers occasionally make their appearance.

VISITORS.—These are probably moths.

413. **S. conica** L.—According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 336), the flowers are protandrous. The anthers of the outer whorl open first, and after they have fallen off, the mature stigmas spread out. The anthers of the inner whorl now dehisce, and by lengthening of their filaments are brought into contact with the stigmas. These stages in anthesis are passed through in the course of a single day.

414. **S. vespertina** Retz.—Kerner states that the flowers of this species open in the evening between seven and eight o'clock.

415. **S. Elisabethae** Jan.—According to Loew—who studied garden specimens—the flowers of the species belong to class **H**. They are protandrous. Though the calyx is wide open, and the claws of the petals diverge considerably, the flowers are often perforated by humble-bees. Kerner states that fruits with seeds capable of germinating are rare.

416. **S. Pumilio** Wulf.—Flowers of this species perforated by humble-bees were found by Kerner in the Taurn.

417. **S. valesiaca** L.—According to Kerner, the flowers of this species open between eight and nine o'clock in the evening.

418. **S. maritima** With.—Plants observed by Warming in the Altenfjord, bore hermaphrodite flowers which exhibited fairly well-marked protandry, though self-pollination was ultimately possible. According to Gibson ('Flora of St. Kilda'), the plant is probably pollinated by flies in St. Kilda, the outermost island of the Scottish west coast—except Rockall, which is barren—for fruits are occasionally formed, though there are no Lepidoptera, bees, nor wasps.

419. **S. inaperta** L. (= S. vilipensa *Kunze*?).—Batalin states that the flowers of this species are completely cleistogamous, with their openings entirely closed by the calyx-teeth.

420. **S. linicola** Gmel.—Kirchner was unable to recognize any secretion of nectar in cultivated specimens of this species. The diameter of the somewhat inconspicuous flowers is at first only 4–5 mm. At the beginning of anthesis five of the ten stamens are so far developed that they dehisce, their pollen-covered anthers coming into contact with the three stigmas, so that automatic self-pollination results. The limbs of the petals subsequently spread out horizontally, increasing the diameter of the flower to 8–9 mm. At this stage the other five stamens elongate until their anthers occupy the mouth of the flower, while the five older anthers wither and fall off.

Visitors.—Only Thrips (larvae and adults) has so far been observed.

421. S. Bastardi Bor.—

Visitors.—Loew observed the bee Halictus sexnotatus *K.* ♀ creeping into the flower in the Berlin Botanic Garden.

422. S. petraea.—Lalanne and Caille (Actes soc. linn., Bordeaux, lxi, 1887), states that this species is dimorphous.

122. Viscaria Riv.

Protandrous butterfly flowers, more rarely homogamous or protogynous. Petals red, with corona and linear claws. Gynomonoecious and gynodioecious, rarely androdioecious or andromonoecious.

423. V. vulgaris Roehl. (= Lychnis Viscaria *L.*). (Herm. Müller, 'Weit. Beob.,' II, pp. 233–4; A. Schulz, 'Beiträge,' II, p. 32; Kirchner, 'Flora v. Stuttgart,' p. 250; Knuth, 'Bloemenbiol. Bijdragen'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—This species bears protandrous butterfly flowers. The red calyx helps to make the flower conspicuous. It is 13 mm. long, but a proboscis of 7–8 mm. is able to reach the nectar without forcing open the mouth of the flower, for the floral axis is prolonged 5 mm. beyond the insertion of the calyx before the petals, stamens, and pistil take origin from it. The rose-red stellate corolla is 18–20 mm. in diameter. The claw of each petal is prolonged into a deeply bifid ligule 3 mm. long, and which is curved outwards in such a way that the entrance of the flower is widened to the extent of 3–5 mm. At the commencement of the anthesis of the hermaphrodite blossom, the five outer stamens, their anthers covered with pollen, are situated between the ligules. The anthers of the five inner stamens—which dehisce either somewhat later or else simultaneously—are placed rather further down in the mouth of the corolla-tube. When the anthers have shed their pollen, the filaments bend outwards and downwards beyond the corolla, while the styles elongate so that the stigmas come to lie above the tips of the ligules. According to Schulz, the hermaphrodite flowers are sometimes homogamous. Besides the bisexual blossoms, unisexual ones have been observed (female, rarely male) on the same or on different stocks (gynomonoecism, gynodioecism, rarely andromonoecism and androdioecism). According to Schulz, the stigmas of purely female flowers do not mature till after the beginning of anthesis.

Warnstorf states that larger and smaller flowers occur at Ruppin. The former are completely hermaphrodite and protandrous. At the time when the pollen is ripe, the styles are still very short, the long stamens with their lilac anthers projecting far beyond them. They elongate subsequently, and protrude far out of the flower. The smaller flowers are at first imperfectly hermaphrodite, afterwards becoming purely female by the absorption of the small yellow anthers of the short stamens, beyond which the styles always project. The pollen-grains of the normal anthers are spherical, white, transparent, almost smooth, and measure about 31–37·5 μ, rarely as much as 50 μ in diameter; while those of the vestigial anthers of the smaller flowers are rounded-polyhedral, delicately papillose, and only about 25 μ in diameter.

VISITORS.—Schulz observed numerous butterflies in the Tyrol, and also flies as unbidden guests. Herm. Müller—in Westphalia—saw a few Lepidoptera effecting cross-pollination (Ino statices *L.* and I. pruni *Schiff.*, skg.), and—as unbidden guests —certain Sphegidae (Gorytes quinquecinctus *F.* ♀) and beetles (Meligethes).

In Thuringia I observed two humble-bees (Bombus soroënsis *F.*, var. proteus, *Gerst.* ☿, and B. terrester *L.* ☿, both skg.). Loew noticed Pieris brassicae *L.*, skg., in the Berlin Botanic Garden.

424. V. alpina Don. (Axell 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 33; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Kirchner, 'Beiträge,' p. 17.)—This species bears protandrous butterfly flowers which possess an odour of vanilla. Kirchner states that they are for the most part bisexual and protandrous at Zermatt, though female stocks are not infrequent. The hermaphrodite blossoms are 10–12 mm. in diameter; the female ones, in which the stamens are reduced so much that they scarcely attain the length of the ovary, are 6–8 mm. in diameter. Warming, in Greenland, besides plants similar to those found by Kirchner at Zermatt, also observed protogynous flowers, and noted the occurrence of smaller gynodioecious female flowers, as well as of intermediate forms between female and bisexual ones. It is doubtful whether purely male flowers exist in Greenland. The same investigator found that this plant is gynodioecious, gynomonoecious, and andromonoecious in Scandinavia. The hermaphrodite flowers are capable of self-pollination in the later stages of anthesis.

VISITORS.—The only one hitherto observed (in Scandinavia) is a butterfly, Argynnis pales *Schiff.*

123. Coronaria L.

Protandrous Lepidopterid flowers. Petals with a ligule and divided or undivided limb. Nectar secretion as usual.

425. C. Flos-cuculi A. Br. (= Lychnis Flos-cuculi *L.*). (Sprengel, 'Entd. Geh.,' p. 261; Herm. Müller, 'Fertilisation,' pp. 129–30, 'Weit. Beob.,' II, p. 232; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' I, pp. 11–12; Loew, 'Blütenbiol-Floristik,' pp. 392, 395; Kirchner, 'Flora v. Stuttgart,' p. 251; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 42, 151.)—The flesh-coloured protandrous flowers, devoid of nectar-guides, secrete nectar at the base of the stamens. The calyx is 6–7 mm. long, with teeth 3 mm. in length, and holds together the claws of the petals. The order of maturation of the stamens and carpels is as usual. The five outer stamens develop first; their anthers occupy the entrance of the flower, and turn their pollen-covered sides towards the centre; when the pollen is shed their filaments elongate and curve outwards, so as to make room for the inner five stamens. The anthers of these now dehisce, and fill the entrance of the flower. The five styles develop last of all, taking the place of the inner stamens. Their ends are spirally twisted, so that the proboscis of an insect, when inserted into the flower, must touch them. Automatic self-pollination may be effected by contact with the stigmas of pollen-grains which have remained clinging to the edge of the corolla-tube.

Besides protandrous hermaphrodite flowers, female or male ones have also been observed, these being gynodioecious and gynomonoecious, or more rarely androdioecious and andromonoecious. In the female flowers, according to Schulz, the stigmas

do not mature till a considerable time after the commencement of anthesis, and the male flowers also remain perfectly fresh after their pollen is shed—a fact which has no significance for the plant. Schulz is of opinion that this peculiarity is obviously inherited from ancestors in which the stigmas were developed subsequently to the shedding of the pollen.

VISITORS.—In the island of Föhr, I saw 2 butterflies, Apis, 2 species of Bombus, and a po-dvg. hover-fly (Syrphus).

Loew—in Brandenburg (Br.) and Hesse (H.)—observed the following (Beiträge, p. 45).—

A. Diptera. *Syrphidae*: 1. Volucella bombylans *L.* (Br.).

B. Lepidoptera. *Sphingidae*: 2. Macroglossa fuciformis *L.* (Br., H.). Rössler noticed the moth Dianthoecia nana *Rott.* in Wiesbaden; Kerner Noctuids—Dianthoecia and Mamestra—in the Tyrol; and Schletterer the following **Hymenoptera** at Pola:—(*a*) *Apidae*: 1. Eucera interrupta *Baer*; 2. E. longicornis *L.* (*b*) *Ichneumonidae*: 3. Tryphon rutilator *Gr.*

Herm. Müller observed the following in Westphalia.—

A. Diptera. *Syrphidae*: 1. Rhingia rostrata *L.*, skg.; 2. Syrphus pyrastri *L.*, po-dvg.; 3. Volucella plumata *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 4. Andrena nitida *Fourcr.* ♀, vainly seeking nectar; 5. Apis mellifica *L.* ☿, freq., skg. and po-cltg.; 6. Bombus agrorum *F.* ♀; 7. B. lapidarius *L.* ♀ and ☿; 8. B. rajellus *K.* ♀; 9. B. terrester *L.* ☿; 10. Osmia rufa *L.* ♀; 11. Psithyrus vestalis *Fourcr.* ♀, skg. **C. Lepidoptera.** (*a*) *Noctuidae*: 12. Euclidia glyphica *L.*, very freq. (*b*) *Rhopalocera*: 13. Lycaena icarus *Rott.*; 14. Pieris brassicae *L.*; and 15. P. rapae *L.*, both freq. (*c*) *Sphingidae*: 16. Ino statices *L.*; 17. Macroglossa fuciformis *L.*

MacLeod saw Apis, 3 humble-bees, 2 hover-flies, and 4 Lepidoptera in Flanders; and H. de Vries (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875) noticed Apis mellifica *L.* ☿ and 2 humble-bees—Bombus agrorum *F.* and B. subterraneus *L.* ☿ in the Netherlands.

In Dumfriesshire 2 humble-bees, 2 hover-flies, and 2 Muscidae have been recorded. (Scott-Elliot, 'Flora of Dumfriesshire,' p. 24.)

426. C. Flos-Jovis Lam. (=Lychnis Flos-Jovis *L.*). (Herm. Müller, 'Alpenblumen,' pp. 199–200.)—This species bears markedly protandrous butterfly flowers, red in colour. The nectar is concealed at a depth of about 10 mm., and owing to the narrowness of the mouth of the flower—which is only 1–2 mm. wide, and largely blocked up by the anthers or styles—it is only conveniently accessible to the proboscis of Lepidoptera. The order of maturation of the five outer and five inner stamens, and the five stigmas is as usual. It may be, however, that automatic self-pollination is possible, for the styles—with half-developed stigmatic papillae—project from the mouth of the flower while pollen still remains clinging to the last anthers, owing to the failure of insect-visits. According to Briquet ('Études de biol. flor. dans les Alpes occident.'), a proboscis of about 15 mm. is necessary to secure the nectar, which is secreted on the inner sides of the bases of the stamens. The visitors are Lepidoptera, which effect cross-pollination, as self-pollination is excluded by the very marked character of the protandry (Kirchner).

VISITORS.—Herm. Müller observed butterflies as regular pollinators (Argynnis, Colias), nect.-skg., and, as an occasional guest, a po-dvg. hover-fly (Eristalis tenax *L.*).

427. C. tomentosa A. Br. (=Agrostemma Coronaria *L.*).—At Bozen, according to Schulz ('Beiträge,' II, p. 33), the large purple-red Lepidopterid flowers of this species conceal their nectar, which is sparingly secreted, at a depth of 12–15 mm. Automatic self-pollination must be a rare occurrence in the protandrous hermaphrodite flowers, for though the stigmas come into contact with the anthers towards the end of anthesis, no pollen remains clinging to these as a rule. Besides bi-sexual flowers, smaller female ones have been observed, which are distributed either gynodioeciously or gynomonoeciously.

Visitors.—Schulz observed many of the larger butterflies (species of Pieris and Vanessa, Papilio machaon *L.* and P. podalirius *L.*).

124. Melandrium Roehl.

Mostly dioecious or trioecious moth or butterfly flowers; more rarely protandrous to protogynous hermaphrodite flowers. Petals with ligule and bifid limb. Secretion of nectar as usual.

428. M. album Garcke (=Lychnis vespertina *Sibth.*, and in part Lychnis dioica *L.*). (Sprengel, 'Entd. Geh.,' pp. 255–60; Herm. Müller, 'Fertilisation,' p. 131; Delpino, 'Ult. oss.,' pp. 161–4; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' I, p. 13, II, pp. 33–5; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 156–7; Kirchner, 'Flora v. Stuttgart,' p. 251; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 41–151.)—The species bears moth flowers, and is almost dioecious. The white petals are devoid of nectar-guides, and appear limp and faded in the daytime. They are odourless and almost completely closed. In the evening they open, the petals spread out, and a strong odour is exhaled. In shady places they are frequently open in the daytime as well, but if exposed to bright sunshine are usually closed from 9 a.m. to 6 p.m. The nectar—as usual—is secreted by the fleshy base of the ovary, and is thoroughly concealed at a depth of 20–25 mm. in female flowers and 15–18 mm. in male flowers. The stamens and styles vary in length according to Schulz. Besides unisexual flowers, hermaphrodite ones have also been observed, which are distinctly protandrous, and are associated with male flowers on the same stocks.

Magnin states ('Recherches sur le polymorphisme floral . . . du Lychnis Vespertina,' Lyon, 1889) that the male flowers are smaller than the female and hermaphrodite ones. The latter are produced by the action of a fungus (Ustilago antherarum *Fries*) upon female blossoms. This fungus causes only a slight change of form of the anthers in male flowers, but in female flowers the styles and upper part of the ovary become vestigial, while the anthers develop because they afford the only nidus in which the fungus can flourish. At the same time, there is an elongation of the internode between calyx and corolla, such as is characteristic for purely male flowers. This phenomenon of 'castration parasitaire androgène' was discovered by Tulasne, and described by Cornu and by Giard ('Sur la castration parasitaire du Lychnis dioica *L.* par l'Ustilago antherarum *Fr.*,' C.-R. Acad. Sci., Paris, cvii, 1888).

Visitors.—*In the island of Amrum I very frequently noticed a moth,* Plusia gamma *L.*; Herm. Müller observed a nocturnal hawk-moth—Deilephila porcellus *L.*—in Westphalia; Rössler saw the moth Dianthoecia nana *Rott.* at Wiesbaden: all skg.

In Dumfriesshire several flies and moths, probably useless guests, have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 23).

429. M. rubrum Garcke (=Lychnis diurna *Sibth.*, and, in part, L. dioica *L.*). (Sprengel, op. cit.; Herm. Müller, op. cit.; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 155–6; Schulz, 'Beiträge,' I, p. 12; Kerner, op. cit.; Loew, 'Blütenbiol. Floristik,' p. 400; Knuth, op. cit.)—The species bears butterfly flowers, and is trioecious. The flower mechanism agrees with that of the last species, but the nectar is concealed at a depth of only 12–15 mm. The calyx-tube is 1½ cm. long in male flowers and 1¼ cm. in female ones. The petals have claws of equal length, and their limbs are nearly 1 cm. longer. They are held so closely together by the calyx that an opening of only 4 mm. in diameter is left. This opening is surrounded by a corona 3–4 mm. high, which contains the anthers in male flowers and the stigmas in female ones. In male flowers the five stamens opposite the sepals mature before the other five, but there are never more than two or three anthers in the entrance of the flower, filling it completely, so that the proboscis of an insect, however slender, must touch them when probing for nectar. The stigmatic papillae are all directed inwards, leaving a passage to the nectar in the middle, so that an insect coming from a male flower must touch them with the part of its body which is dusted with pollen if it wishes to get at this. In the female flowers nectar is secreted on the base of the ovary, in male flowers on the inner sides of the bases of the filaments, where the vestigial pistil is situated. In male flowers the nectar is protected by hairs on the lower thirds of the filaments, and perpendicular to their surfaces, while in female flowers the somewhat overhanging ovary serves the same purpose (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 41).

Besides unisexual flowers, hermaphrodite ones have been locally, though rarely, observed, e. g., by Schulz at Halle a. S. They are markedly protandrous.

Visitors.—As a regular pollinator of the faintly odorous flowers, I observed—at Kiel—only Bombus hortorum *L.* Apis only paid brief visits, soon going off to some other species. The male flowers were also visited by po-dvg. Syrphidae (Eristalis, Melanostoma). On the Dovrefjeld Lindman also noticed humble-bees and flies, while Herm. Müller in the Alps saw 12 Lepidoptera and a hover-fly ('Alpenblumen,' p. 200).

Rössler observed the moths Dianthoecia filigrana *Esp.* and B. nana *Rott.* at Wiesbaden; Loew—at Varenna ('Beiträge,' p. 63)—saw a hover-fly, Leucozona lucorum *L.*, endeavouring to suck nectar.

H. de Vries (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875) noticed a humble-bee, Bombus terrester *L.*, in the Netherlands.

Willis ('Flowers and Insects in Gt. Britain,' Part I) observed the following in the neighbourhood of the south coast of Scotland:—A. **Diptera,** *Syrphidae*: 1. Platycheirus albimanus *F.*, on ♂ flowers only, po-dvg. B. **Hymenoptera,** *Apidae*: 2. Bombus terrester *L.*, freq., skg.

In Dumfriesshire 3 humble-bees and 2 hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 24).

The flowers are sometimes perforated by humble-bees (Schulz).

430. M. apetalum Fenzl (=Wahlbergella apetala *Fr.*).—This northern species certainly does not bear Lepidopterid flowers. Lindman could not find any nectar in the flowers, although there are nectaries in the form of small swellings on the inner

sides of the bases of the stamens. The small petals project from the calyx but little or not at all. In Greenland plants self-pollination is inevitable. They develop fruits as far as 70° or 71° N. lat. Lindman was able to distinguish two varieties in Norway, the larger of which possessed a greater proportion of female flowers, with enclosed dirty red petals and shorter stamens; while the smaller variety had more male flowers, with projecting expanded petals of yellow colour, and longer stamens. Warming observed in Nova Zemlia a variety intermediate between these two forms, with petals of medium length, and capable of autogamy. The same observer saw in Greenland and Norway flowers that looked normal, but had no pollen and were therefore female. According to Ekstam, Nova Zemlian plants agree with those native to Greenland (Loew, 'Blütenbiol. Floristik,' p. 100).

Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 55) state that the arctic variety of this species (Wahlbergella apetala *Fr.*, var. arctica *Th. Fr.*) flowers in Spitzbergen from the beginning of July to the middle of August, regularly setting fruits in the latter month. As a rule the plant only bears one flower, or more rarely two. The calyx is dark red—in plants from Greenland (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 15) with reddish-violet veins on a green ground—and the scarcely longer corolla dirty violet. The entrance of rain is prevented by the pendulous nature of the flower, and by its narrow opening. The pollen-grains are normal, and quickly germinate in distilled water. Self-pollination is the rule, for the anthers are in immediate contact with the twisted stigmas.

Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 24) describes the plant as dioecious (?), perhaps on the strength of two somewhat different sexual forms observed by Lindman on the Dovrefjeld. He only makes special mention, however, of hermaphrodite and female flowers.

VISITORS.—Ekstam saw none in Spitzbergen.

431. **M. involucratum** Cham. et Schlecht, var. Baffine *Rohrb.* (= Wahlbergella affinis *Fries.*).—This plant has been studied by Warming in Greenland. The faintly odorous flowers possess more or less projecting petals. It is doubtful whether they belong to Class **L.** The flowers are at first protogynous, but automatic self-pollination is possible in the later stages of anthesis. Fruits are ripened as far as 70° or 71° N. lat., and—in Grinell Land in Arctic America—even as far north as 84°; they have also been found in Spitzbergen and Nova Zemlia. In Norway purely female flowers have been observed (Loew, op. cit.).

According to Andersson and Hesselman (op. cit., p. 56), this species flowers in Spitzbergen from the middle of June on. Ripe fruits were collected by Ekstam on August 7, 1897. The plants usually bore only one or two flowers, rarely three. The petals project beyond the cylindrical calyx for $\frac{1}{3}$–$\frac{1}{2}$ its length. Ekstam (op. cit., p. 25) determined the diameter of the flowers to be 12–13 mm. The hermaphrodite blossoms are protogynous to homogamous, and secrete nectar on the inner sides of the bases of the filaments.

VISITORS.—Ekstam observed none in Spitzbergen.

432. **M. triflorum** J. Vahl.—According to Warming, who studied this northern species in Greenland, it is doubtful whether it belongs to Class **L.** The flowers are

faintly odorous, and the petals more or less spreading. There is slight protogyny, but self-pollination is inevitable later on, and is effective, for fruits are regularly set, even in 76° N. lat. In Greenland, at 73° N. lat., purely female flowers have also been observed (Loew, op. cit.).

433. **M. divaricatum** Nym. (=M. macrocarpum *Willk.*).—Focke considers that the greatly dilated calyx of this South European species is a means of protection against the ovipositor of insects. The opposite is true—according to the same investigator—for

434. **M. album × Silene noctiflora,** the calyx of which is narrower than that of M. album. This hybrid is therefore not so well protected against such attacks.

125. Agrostemma L.

Protandrous to homogamous butterfly flowers. Petals red, undivided, without ligules; the lower parts of the claws are winged and held together by the calyx, which is contracted above. Secretion of nectar as usual.

435. **A. Githago** *L.* (=Lychnis Githago *L.*, Githago segetum *Desf.*). (Sprengel, 'Entd. Geh.,' pp. 254–5; Herm. Müller, 'Fertilisation,' p. 131, 'Weit. Beob.,' II, p. 234; Tullberg, Bot. Not., Lund, v, 1868, p. 10; Kerner, 'Nat. Hist. Pl.,' Eng. Ed., I, II; Kirchner, 'Flora v. Stuttgart,' pp. 252–3; Schulz, 'Beiträge,' I, p. 11; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 157; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 42, 151.)—The purple petals of this species close neither at night nor during bad weather. At the bases of their limbs there are whitish spots with dark purple lines and blotches. The secretion of nectar is as usual. The stamens and stigmas mature serially after the fashion of most other species of the order. Besides plants bearing the ordinary hermaphrodite blossoms there are also varieties with smaller flowers, distinguished by better developed carpels and less pronounced nectar-guides. Tullberg observed transitions between protandry and homogamy in Sweden. Schulz also describes the hermaphrodite flowers as varying from protandry to homogamy, autogamy taking place in the latter case. Kerner states that continued growth of the stamens always brings about automatic self-pollination towards the end of anthesis. According to Schulz, autogamy and xenogamy may both take place in the same field, though they are often restricted to different localities. Besides hermaphrodite flowers female ones also occur, these being gynodioeciously, or rarely gynomonoeciously distributed.

Visitors.—In the island of Amrum I saw only a butterfly—Pieris brassicae *L*—skg. normally; also a fly, which was a useless guest. Herm. Müller observed the following in Central Germany.—

A. Diptera. *Syrphidae*: 1. Rhingia rostrata *L.*, vainly seeking nectar. **B. Lepidoptera.** (*a*) *Rhopalocera*: 2. Hesperia lineola *O.*, skg.; 3. H. sylvanus *Esp.*, skg.; 4. H. thaumas *Hfn.*, skg.; 5. Pieris brassicae *L.*, very freq., skg. (*b*) *Sphingidae:* Ino statices *L.*, skg.

2. Tribe Alsineae DC.

Literature.—Herm. Müller, 'Fertilisation,' pp. 131–8; Knuth, 'Grundriss d. Blütenbiol.'; Schulz, 'Beiträge,' I, pp. 25–6, II, pp. 52–5.

The small flowers are usually but slightly conspicuous, even when aggregated into inflorescences. The polysepalous calyx permits the petals to spread out. This takes place in the sunshine, the nectar secreted in the base of the flower at the same time becoming visible, so that the Alsineae all belong to Class **EC**. The nectar is therefore accessible to insects with a very short proboscis; flies and the less specialized bees have chiefly been observed as visitors. Many Alsineae are dichogamous, in which case they are almost always protandrous, but sometimes protogynous. Homogamy is less frequent. The degree of dichogamy is proportionate to the conspicuousness of the flowers and the number of insect visitors. Automatic self-pollination is probably possible in all species, but is more certain in its action when the flowers are inconspicuous, and insect visits few, either on this account or owing to unfavourable weather.

Schulz ('Beiträge,' I, pp. 25–6), adds the following particulars.—In many cases the normal number (ten) of stamens is not developed. In certain species (Spergularia salina *Presl*, Holosteum umbellatum *L.*, Cerastium semidecandrum *L.*, [also C. tetrandrum *Curt.*]) the full number is never or rarely present; in others (Sagina Linnaei *Presl*, Stellaria media *Cyrill.*) this is more frequently the case. In most instances several, or all, of the inner stamens disappear, while even some of the outer ones do so; e.g. Spergularia salina, Holosteum umbellatum, and Stellaria media commonly possess but three outer stamens. Vestiges of the filaments are usually retained, and commonly small anthers devoid of pollen; more rarely the stamens have completely disappeared. In most species purely female stocks occur, often in great numbers, but sometimes sporadically. In certain species hermaphrodite and female flowers are found on the same plant. Male flowers have not been recorded. The female flowers are usually at once distinguishable by their smaller size. Among small-flowered species, female stocks are much less frequent than among large-flowered ones. In several species where some of the stamens are almost always aborted—it may be even some of the outer ones—female flowers are rare. There are both individual species possessing small flowers—and therefore attracting insects but little—which are protandrous, and large-flowered species that are homogamous. On the whole, however, the small-flowered species are either homogamous or but slightly protandrous.

With regard to the development of the reproductive organs, and so forth, Schulz (Beiträge,' II, pp. 52–5) speaks somewhat as follows.—

The anthers of the outer stamens usually dehisce very soon after the flower opens, their filaments, in many species, bending inwards, and frequently meeting above the ovary. Sooner or later, after the dehiscence of the outer anthers, those of the inner stamens, of which the filaments are either erect or else more or less inclined towards the petals, also begin to shed their pollen. At this time the outer anthers in some species still contain abundant pollen; in other species they are almost or entirely empty; and in yet other species, e.g. in Alsine verna, some or all of them have dropped off. There are but a few species in which both sets of anthers dehisce simultaneously. The anthers of the same whorl dehisce either altogether or within a short time—usually only a few minutes—of one another. In the latter case no species exhibits any definite order. The anthers at first have an introrse position, but in most species, either before or during dehiscence, or rarely towards its end,

they assume a horizontal or completely extrorse position. The styles and stigmas in most species are not fully developed when the flower opens, or at the time the shedding of pollen begins.

In some species, however, the stigmas are regularly mature and receptive during the dehiscence of the outer or at any rate of the inner anthers. In other species the stigmas are mature only when the inner stamens have discharged almost all their pollen, and in yet other species—e. g. Alsine verna and Stellaria graminea—they become receptive only after all the empty inner anthers, or at least those of them which first dehisce, have fallen to the ground. There are but few species in which the stigmas are receptive when the outer anthers are beginning to open. Automatic self-pollination is almost inevitable in those species where the stigmas are receptive while the anthers of the outer stamens—which often bend inwards—are dehiscing. Self-pollination is much less likely when the stigmas first mature while pollen is being shed from the anthers of the erect or more or less outwardly inclined inner stamens. It is, of course, quite impossible when the stigmas become receptive only after the anthers have lost their pollen, or when all or some of them have fallen to the ground. The hermaphrodite flowers of but few species regularly possess the typical number of stamens: in most species some or all of the inner stamens are wanting in a larger or smaller proportion of the flowers, and less frequently one, two, or even three of the outer stamens are absent. In some species the normal number of stamens is rare, in a few it is very rare, and in a small percentage it seems never to have been observed. In almost all cases—Moenchia erecta and Moehringia trinervia apparently alone excepted—female flowers make their appearance, being far more numerous in species which possess the typical number of stamens than in those which rarely or never do so. The female flowers are usually to be found on separate plants. They are much less frequently—in some species but very rarely —associated with hermaphrodite flowers on the same stocks. In some species, however, such an association is almost always the rule. The female flowers are smaller than the hermaphrodite ones, but in nearly all species both kinds often vary greatly in size. In female flowers the stamens have either entirely disappeared or are reduced to more or less considerable vestiges. In the latter case remains of the anthers commonly occur, the largest of these being often but little smaller than the normal and typical ones. They are almost always white or discoloured yellow, but now and then contain a few normal pollen-grains capable of germination, as well as small abnormal polyhedral or rounded ones. The styles of female flowers are often somewhat longer, and stigmas stouter, closer, and beset with longer papillae, than those of hermaphrodite ones. In almost all Alsineae there is a tendency for the flowers to close more or less completely—or at least to contract—during the night, and in cool, moist weather. In many species when the flowers close completely at night, and in bad weather, they remain open all day when the weather is bright and warm. In other species the flowers remain open in such weather only during the middle of the day, while in some species, e.g. Sagina Linnaei, var. macrocarpa, it appears that they only open when there has been warm weather for at least five or six hours previously. Other species, again, such as Sagina Linnaei, var. micro-carpa, and Stellaria media, var. pallida (S. Boraeana *Jord.*), have taken a further step towards cleistogamy, for they frequently do not open even during long periods of

warm weather. Stellaria media, var. pallida, is indeed in some places completely cleistogamous. Most species secrete nectar very abundantly. This usually trickles down from the nectaries between the bases of the petals on to the spoon-shaped sepals, which often project horizontally. The larger flowers of some species relatively poor in nectar are visited much less than the smaller flowers of other species which are more richly supplied. But the small flowers of some species which secrete a comparatively large quantity of nectar—e. g. those of Arenaria serpyllifolia and Sagina Linnaei, var. macrocarpa—remain almost unvisited. Probably this difference as regards visits depends upon variations in the composition of the nectar: presumably that of Arenaria serpyllifolia and similar species are deficient in certain odorous substances, so that insects have difficulty in detecting it.

The following species are known to be gynodioecious (gd.) or gynomonoecious (gm.).—

Sagina nodosa *Fenzl*, gd. in Denmark (Warming) and Belgium (MacLeod);

S. Linnaei *Presl*, gd. and gm. (Schulz);

Spergula arvensis *L.*, gm., more rarely gd. (Schulz);

S. vernalis *Willd.*, and S. pentandra *L.*, gm. and gd. (Schulz);

Spergularia media *Presl*, gd., rarely gm. (Schulz);

S. salina *Presl*, ditto;

S. rubra *Presl*, gm. and gd., as also Alsine verna *Bartl.*, Cherleria sedoides *L.*, Mochringia muscosa *L.*, Arenaria serpyllifolia *L.*, A. biflora *L.*, A. ciliata *L.*, Holosteum umbellatum *L.*, Stellaria nemorum *L.*, S. media *Cyr.*, S. Holostea *L.*, S. uliginosa *Murr.* (mostly according to Schulz);

S. graminea *L.*, gm. (MacLeod);

S. palustris *Ehrh.*, gd. (Warming, Ludwig, Müller);

S. graminea *Retz.*, gd. (Tullberg, Warming, Müller, Ludwig, Schulz);

Malachium aquaticum *Fries*, gd. (Ludwig) and gm. (Schulz);

Cerastium arvense *L.*, gd. and gm. (Schulz);

C. triviale *Link*, gd. (Ludwig), and gm. (Schulz);

C. glomeratum *Thuill.*, gd. (Ludwig);

C. brachypetalum *Desp.*, gm., moderately gd. (Schultz), so also for C. semidecandrum *L.*, C. pallens *F. Schultz*, C. obscurum *Chaub.*, C. trigynum *Vill.*, and C. latifolium *L.*;

C. alpinum *L.*, gd. (Ludwig).

126. Sagina L.

Small whitish, protandrous, homogamous or protogynous flowers, with half-concealed nectar secreted at the bases of the stamens.

436. **S. procumbens** L. (Schulz, 'Beiträge,' II, pp. 38–9.)—There are four small nectaries at the bases of the filaments. The white petals, usually four in number, are smaller than the sepals, of which an equal number are present. The four or five stamens develop simultaneously with the four or five stigmas. Automatic self-pollination is inevitable, for the flowers remain closed in dull weather. In Greenland, according to Warming, the anthers, even in the open flower, come into contact with the short, greatly spreading styles. The same investigator observed female flowers as well as hermaphrodite ones in Denmark.

VISITORS.—Schulz noticed a few small flies and bees. MacLeod observed ants, Poduridae, and Acaridae in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 159).

In Dumfriesshire several ants have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 25).

437. **S. apetala** L. (MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 159; Kirchner, 'Flora v. Stuttgart,' p. 234.)—The flower mechanism essentially agrees with that of the last species. The flowers are very feebly protandrous, and their petals—which are very small, wanting altogether, or at least soon disappear—open in sunshine, and the nectaries are situated as in the last species. During anthesis the stamens incline inwards to such an extent that the anthers touch the stigma, and automatic self-pollination necessarily results. In dull weather it takes place at once, for the flowers remain closed.

VISITORS.—Acaridae have been observed in Belgium, and MacLeod has also seen Poduridae, ants, and mites which are able to effect cross-pollination.

438. **S. maritima** D. Don.—The flower mechanism of this species, which I studied in the Halligen, agrees essentially with that of the last species.

VISITORS.—I did not observe any.

439. **S. Linnaei** Presl (=S. saxatilis *Wimm.*).—In the Alps, according to Schulz ('Beiträge,' II, pp. 14–15), the hermaphrodite flowers of this species are homogamous or slightly protogynous. In dull weather automatic self-pollination takes place, for the flowers remain closed. Kerner says that when the flowers have opened the five outer stamens serve for cross- and the five inner stamens for self-pollination. Besides hermaphrodite blossoms there are also female ones, distributed either gynodioeciously, or gynomonoeciously. In the Riesengebirge Schulz observed a large-flowered variety rich in nectar, and with partially degenerate stamens. Warming saw ripe fruits in Greenland.

VISITORS.—Schulz noticed flies and small beetles.

440. **S. nivalis** Fries.—According to Lindman, this species is autogamous on the Dovrefjeld, and Warming states that it occurs and sets fruits in Spitzbergen and on the north coast of Siberia. For Nova Zemlia Ekstam describes the flowers as being odourless, protogynous-homogamous (sometimes homogamous) and 5 mm. in diameter. Self-pollination is inevitable.

Andersson and Hesselman state ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 65) that this species flowers in Spitzbergen from the second half of July to the middle of August, its fruits maturing regularly and abundantly towards the end of the latter month and the beginning of September. The petals of Greenland specimens are either shorter than the calyx or of the same length (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' p. 17).

441. **S. caespitosa** J. Vahl.—Warming states that this species is homogamous and autogamous in Greenland, where it has been observed to set fruits. Gynodioecism obtains in Norway, the female flowers possessing more or less degenerate stamens.

442. **S. nodosa** Fenzl.—The hermaphrodite flowers of this species are protandrous in Norway and Denmark—according to Warming—and also in Russia

(Batalin, Bot. Ztg., Leipzig, xxviii, 1870). During unfavourable weather the flowers remain closed, and self-pollination takes place. MacLeod observed (Bot. Centralbl., Cassel, xxix, 1887) female as well as hermaphrodite flowers on the dunes of the Flemish coast. Female stocks were also noticed by Warming in Denmark.

Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) observed gynodioecism and imperfect gynomonoecism at Ruppin. He distinguished—(1) larger hermaphrodite flowers of 10 mm. diameter, frequently with more or less reduced anthers or stamens: and (2) smaller flowers of only 5–6 mm. diameter, and female by abortion of all the stamens. The hermaphrodite flowers are protandrous. The first stamens to mature are the outer ones, which have nectaries at their bases. These incline over the still apposed stigmatic branches. The inner stamens ripen subsequently. Nectar is abundantly secreted.

Visitors.—Hermann Müller ('Alpenblumen,' p. 183) observed one of the Bombyliidae—Anthrax sp.—in the Alps.

443. **S. subulata** Torr. et Gray.—Garden plants were found by Warming to be sometimes protogynous, sometimes slightly protandrous.

127. **Spergula** L.

Flowers white, usually homogamous, rarely protogynous, with half-concealed nectar, secreted by nectaries situated as usual.

444. **S. arvensis** L. (Herm. Müller, 'Weit. Beob.,' II, p. 225; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' I, pp. 15–16; Kirchner, 'Flora v. Stuttgart,' p. 232; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 43, 'Bloemenbiol. Bijdragen'.)—The white homogamous flowers of this species open widely in the sun, and secrete nectar near the bases of the stamens. The filaments are meanwhile curved outwards to such an extent that insects in quest of nectar touch the anthers with one side of their body, and the stigma with the other, so that cross-pollination is promoted. During unfavourable weather the flowers remain closed, and self-pollination takes place. Further—according to Kerner—automatic self-pollination occurs towards the end of anthesis, when the flowers are beginning to close. The same writer states that they remain closed from 10 a.m. till 4 p.m. According to Schulz, female flowers frequently occur, and over 50% of them may be gynomonoecious in a given locality, while gynodioecism is rare. Schulz also says that the number of stamens varies, for some of them are often more or less vestigial. Normal and abnormal flowers are sometimes associated on the same stock, or may occur on different ones.

Visitors.—Hermann Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Lucilia sp., skg. (H. M.). (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*, skg. and po-dvg. (H. M.); 3. E. tenax *L.*, ditto (Kn.); 4. Helophilus pendulus *L.*, ditto (H. M.); 5. Melanostoma ambigua *Fall.*, ditto (H. M.); 6. Melithreptus menthastri *L.*, ditto (H. M.); 7. M. strigatus *Staeg.*, ditto (H. M.); 8. Syritta pipiens L., ditto (H. M., Kn.); 9. Syrphus balteatus *Deg.*, ditto (H. M., Kn.); 10. S. corollae *F.*, ditto (H. M.); 11. S. ribesii *L.*, ditto (H. M., Kn.). **B. Hymenoptera.** (*a*) *Apidae*: 12. Andrena albicrus *Müll.* ♀, po-cltg. (H. M.); 13. A. convexiuscula *K.* ♂, skg. (H. M.); 14. Apis mellifica *L.*, skg. (Kn.); 15. Halictus malachurus *K.* ♀, skg. and po-dvg. (H. M.). (*b*) *Sphegidae*: 16. Crabro wesmaëli *v. d. L.* ♀, skg. (H. M.).

MacLeod saw two hover-flies and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 158).

In Dumfriesshire an Empid, three Muscidae, and five hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 31).

445. **S. pentandra** *L.*—According to Schulz ('Beiträge,' II, p. 41), the flowers of this species are open from noon till 5 p.m. They are homogamous, and, as a rule, only five stamens are present. These are usually erect in the open flower, or spread somewhat outwards, so that the anthers do not generally come into contact with the stigma. As the flowers, however, soon close and in dull weather do not open at all, automatic self-pollination takes place, while in the open flowers cross-pollination is favoured by insect-visits. In addition to hermaphrodite flowers female ones sometimes occur, these being distributed gynomonoeciously or gynodioeciously.

446. **S. Morisonii** Bor. (=S. vernalis *Willd.*, in part).—Schulz states ('Beiträge,' II, pp. 39–41) that the hermaphrodite flowers of this species are homogamous in North Thuringia, but when the flowers are open—between noon and 5 p.m.—the anthers do not usually touch the stigmas. Of the ten stamens a few are commonly vestigial, and sometimes none are developed, so that the flowers become female. Such female flowers are smaller than the hermaphrodite ones, and are distributed either gynomonoeciously or gynodioeciously. Cross-pollination is favoured by insect-visits, but automatic self-pollination takes place when the flowers close. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) observed only homogamous and autogamous hermaphrodite flowers at Ruppin.

128. Spergularia Presl.

Flowers white or red, varying from marked protandry to homogamy, with nectar half concealed.

447. **S. media** Poir. (= S. marginata *Kitt.*, and Arenaria marginata *DC.*).—Schulz states that the red or white hermaphrodite flowers of this species are distinctly protandrous at Halle. All ten stamens are usually developed. Besides hermaphrodite flowers, smaller female ones have been occasionally observed—e. g. by MacLeod on the Belgian coast—and the plants in such cases are gynodioecious, more rarely gynomonoecious.

Visitors.—I observed small Diptera—sp. of Hilara and Hydrellia—in the Halligen.

448. **S. salina** Presl (=Arenaria rubra β marina *L.*, S. marina *Griseb.*, Arenaria marina *Roth*, and Lepigonum medium *Wahlenb.*).—The flowers of this species investigated by MacLeod on the Belgian coast were very similar to the female flowers of the last species. The petals are rose-red; only 1–3 stamens are developed; automatic self-pollination is ensured.

Schulz examined the flowers by the Salt Lake at Eisleben, where they appear to be considerably smaller than in Belgium. The petals are shorter than the sepals; frequently but three stamens are developed, which usually mature rather sooner than the stigmas, these being at the same level. The nectar is secreted by a fleshy ring internal to the bases of the stamens. In unfavourable weather the flowers remain closed, so that automatic self-pollination necessarily takes place.

All the flowers observed by Magnus at Kissingen showed a transition to cleistogamy, the pale corolla remaining closed.

Besides hermaphrodite flowers, Schulz noticed female ones, distributed gynomonoeciously, more rarely gynodioeciously.

VISITORS.—I saw the honey-bee skg. in the island of Sylt ('Weit. Beob.,' p. 232).

Verhoeff observed the following in Norderney.—

A. Diptera. (*a*) *Empidae*: 1. Hilara quadrivittata *Mg.*; (*b*) *Muscidae*: 2. Anthomyia sp., skg.; 3. Aricia incana *Wiedem.*, skg.; 4. Lucilia caesar *L.* ♂, skg.; (*c*) *Syrphidae*: 5. Syritta pipiens L., skg.

449. S. rubra Presl (=Arenaria rubra and campestris *L.*, Alsine rubra *Wahlenb.*, and Lepigonum rubrum *Wahlenb.*).—According to Schulz ('Beiträge,' I, p. 17), the flower mechanism of this species resembles that of S. salina, and there is also an agreement as regards the small number of stamens. The flowers vary from homogamy to slight protandry, and, as in the last species, self-pollination often takes place when they remain closed. There are female flowers as well as hermaphrodite ones. These are usually smaller, and may be distributed either gynomonoeciously or gynodioeciously. Schulz regards this species as oecologically intermediate between S. media and S. salina.

VISITORS.—MacLeod observed an Empid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, *1894*, p. *157*).

129. Cherleria L.

Flowers protandrous to homogamous, and very inconspicuous, with half-concealed nectar secreted between the roots of the stamens.

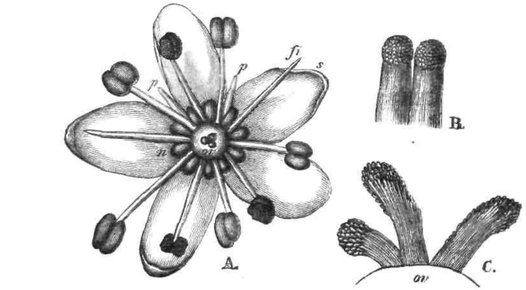

FIG. 51. *Cherleria sedoides, L.* (after Herm. Müller). *A.* Flower seen from above (× 16). *B.* Styles and stigmas in the first (male) condition. *C.* The same in the second (female) condition. *s*, sepals; *p*, petals; *fi*, filaments; *n*, nectaries; *ov*, ovary.

450. C. sedoides L. (Herm. Müller, 'Alpenblumen,' pp. 184–5; Schulz, 'Beiträge,' II, pp. 44–5.)—In this species the petals scarcely attain one-third the length of the sepals. The expanded calyx is star-shaped and 4–5 mm. in diameter.

Hermann Müller says that in the Alps the hermaphrodite flowers are distinctly protandrous, so that automatic self-pollination is usually prevented. Schulz examined

plants not far from the same district, and found them homogamous or slightly protandrous. Besides hermaphrodite flowers, he also observed female ones, distributed gynodioeciously or gynomonoeciously.

VISITORS.—Herm. Müller observed numerous small nect-skg. flies.

130. Alsine L.

Flowers white, usually small, protandrous, homogamous or protogynous, with half-concealed nectar.

451. **A. verna** Bartl. (=A. Gerardi *Wahlenb.*). (Herm. Müller, 'Alpenblumen,' pp. 183–4; Schulz, 'Beiträge,' I, p. 18.)—In the Alps, according to Hermann Müller, the flowers of this species attain a diameter of 6 mm. Schulz states that at a height of 2,000–3,000 m. it is as much as 7–9 mm., while in the Riesengebirge it averages 10 mm. There is marked protandry (see Fig. 52), and Schulz asserts that self-pollination does not take place, though Kerner says that it occurs towards the end of anthesis, while according to MacLeod it is brought about by the closing of the flowers in the evening. Smaller female flowers have been observed, in addition to hermaphrodite ones, especially in the Hochgebirge. They are distributed gynomonoeciously and gynodioeciously.

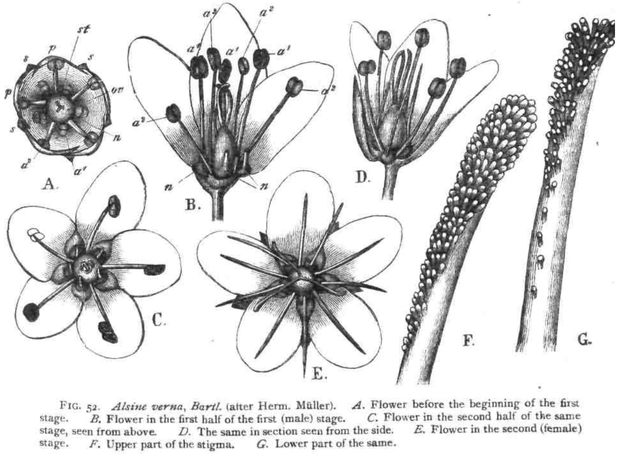

FIG. 52. *Alsine verna, Bartl.* (after Herm. Müller). *A.* Flower before the beginning of the first stage. *B.* Flower in the first half of the first (male) stage. *C.* Flower in the second half of the same stage, seen from above. *D.* The same in section seen from the side. *E.* Flower in the second (female) stage. *F.* Upper part of the stigma. *G.* Lower part of the same.

The hermaphrodite flowers seen by Warming in Greenland—belonging to the variety (*b*) *hirta* Lange—were almost homogamous, and capable of self-pollination. In Spitzbergen the same botanist observed cases of protogyny, representing perhaps a transition towards the female condition.

VISITORS.—Those observed by Müller and A. Schulz in the Alps were chiefly Diptera (Muscidae, Syrphidae, Empidae, Bombyliidae), some beetles, ants, and Lepidoptera (Pyralidae). MacLeod also saw Diptera in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 379–81).

452. **A. recurva** Wahlenb. (Herm. Müller, 'Alpenblumen,' p. 182.)—Hermann Müller says that some of the flowers remain open, while others half close.

VISITORS.—Diptera (Syrphidae, Muscidae) and some Lepidoptera have been observed in the Alps.

453. **A. stricta** Wahlenb.—According to Warming, the flowers of this species are homogamous in Greenland and Norway. Automatic self-pollination takes place and is effective, for ripe fruits are regularly produced even as far north as 70°–71° N. lat.

454. **A. rubella** Wg.—Ekstam states that the odourless, protogynous to homogamous flowers of this species are 5–8 mm. in diameter in Nova Zemlia. The stigmas being usually at a higher level than the anthers, self-pollination is rendered difficult.

This species flowers on Spitzbergen throughout July, and fruits are ripened very early (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 65).

455. **A. groenlandica** Fenzl.—In Greenland—according to Warming—the flowers of this species are either slightly protandrous or else quite homogamous, so that self-pollination is almost inevitable.

456. **A. biflora** Wg.—The hermaphrodite flowers of this species are protandrous on the Dovrefjeld, but automatic self-pollination takes place when the flowers close. The plants examined in Greenland by Warming bore slightly protandrous, homogamous, or even slightly protogynous hermaphrodite flowers, in which automatic self-pollination necessarily occurred. This resulted in the abundant production of fruits. In Spitzbergen the flowers are smaller, and gynodioecism has been observed in Norway.

According to Andersson and Hesselman (op. cit., p. 64), this species flowers in Spitzbergen from the beginning of July till September. By the beginning of August fruits are abundantly and regularly ripened. Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' pp. 28–9) gives 5–7 mm. as the diameter of the flowers. There appear to be variations in regard to the maturation of the sexual organs. In Greenland specimens the petals are about half as long again as the calyx (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' p. 17).

457. **A. Rossii** Fenzl.—This species has only once been found in flower in Spitzbergen (Andersson and Hesselman, op. cit., p. 64).

131. Honckenya Ehrh.

Flowers white, protandrous, with half-concealed nectar secreted as usual.

458. **H. peploides** Ehrh. (=Ammodenia peploides *Rup.*, Arenaria peploides *L.*, and Halianthus peploides *Fries*).—The plants examined by me in the North Frisian Islands ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 44) spread out their flowers in the

sunshine, forming an almost plate-like disk, measuring about 8 mm. in diameter. The five white spathulate petals are about the same length as the bright green sepals. Of the ten stamens, the five opposite the sepals mature first. They are then nearly erect, and project from the flower about 1 mm. The five other stamens—which have meanwhile rested on the petals—next mature, elongating till they are as long as the outer ones. It is only at this stage that the stigmas unfold. At the base of the ovary there is a large yellow nectary between each pair of stamens, which secretes so abundantly that the intervals between the pairs of stamens are completely filled with nectar.

In spite of its abundant nectar the flower is seldom visited by insects. I saw no visitors in the island of Röm, though I watched for a long time during fine weather. From dehisced anthers, however, pollen frequently falls into the flower, and this may be carried by the wind to the stigmas of the same plant, or of neighbouring ones. Small grains of sand are constantly to be found in the flowers, into which they have been drifted by the wind, and as these may be blown along from blossom to blossom they possibly serve as occasional agents of pollination. During dull weather the flowers close, so that automatic self-pollination is then possible.

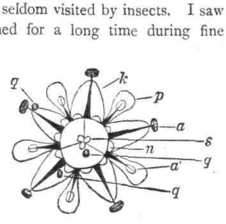

FIG. 53. *Honckenya peploides, Ehrh.* (from nature. Semi diagrammatic). Flower in the first half of the first (male) stage, seen from above. *k*, sepal; *p*, petal; *a*, stamen of the outer whorl with dehisced anther: *a'*, stamen of the inner whorl, with anther still closed; *s*, immature stigma; *q*, sand-grain.

In Greenland, Iceland, north Norway, Spitzbergen, and Nova Zemlia—according to Warming—hermaphrodite flowers are very rare, and dioecism, polyoecism, or monoecism almost always obtains. Warming observed fruits to be set in Greenland.

This species flowers in Spitzbergen from the beginning of July to August (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 64). Ekstam observed ripe fruit there on August 24, 1897. Both female and hermaphrodite flowers were found. The latter are protandrous and odourless, with a diameter of 9–11 mm., and with functional nectaries at the bases of the filaments.

VISITORS.—On the dunes of Helgoland, I observed (June 8, 1895) 2 Muscidae—Lucilia caesar *L.*, and Fucellia fucorum *Fall.*—both skg. Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 28) observed no visitors in Spitzbergen.

Verhoeff observed the following 2 Muscidae in Norderney:—1. Lucilia caesar *L.*, ♀ and ♂, skg. 2. Scatophaga stercoraria *L.*

In Dumfriesshire 2 Muscidae have been recorded, freq. (Scott-Elliot, 'Flora of Dumfriesshire,' p. 26).

132. Moehringia L.

Flowers white, homogamous, protandrous or protogynous, with half-concealed nectar.

459. **M. trinervia** Clairv. (=Arenaria trinervia *L.*). (Herm. Müller, 'Fertilisation,' 136–7, 'Weit. Beob.,' II, p. 225; Warnstorf, Verh. bot. Ver., Berlin,

xxxviii, 1896; Schulz, 'Beiträge,' II, pp. 46–7; Kirchner, 'Flora v. Stuttgart,' p. 235.)—Hermann Müller describes the flowers as protogynous, with stigmas persisting for a long time, while A. Schulz found them to be almost always homogamous, though sometimes slightly protandrous or slightly protogynous. At the base of each of the five outer stamens there is a fleshy swelling, which secretes a relatively large drop of nectar. The anthers of the five outer stamens dehisce first. Insect visitors regularly effect cross-pollination, for they touch the stigmas before the anthers. Failing insect-visits, automatic self-pollination takes place, the stamens gradually curving inwards till they touch the stigmas. Sometimes the anthers of the five outer stamens are vestigial.

Warnstorf states that the flowers are homogamous and autogamous at Ruppin. The long stigmatic branches—usually three, more rarely two—curve outwards, often becoming hook-shaped, and arch over the stamens in such a way that self-pollination necessarily results. Self-pollination also takes place by apposition of the stamens to the stigmas. The styles are rarely vestigial. The parts of the flower are frequently in fours.

Visitors.—The inconspicuous odourless flowers, with petals shorter than the sepals, are but rarely visited by insects.

Hermann Müller observed the following.—

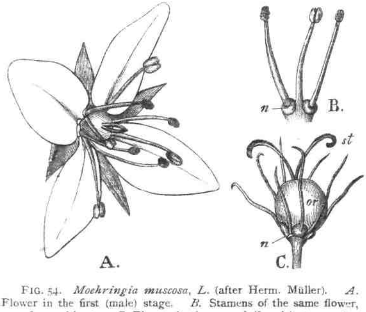

FIG. 54. *Moehringia muscosa, L.* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Stamens of the same flower, seen from without. *C.* Flower in the second (female) stage, after removal of calyx and corolla.

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes, nect-lkg. (*b*) *Phalacridae*: 2. Olibrus affinis *Sturm.*, nect-lkg.

B. Diptera. (*a*) *Bibionidae*: 3. Dilophus vulgaris *Mg.*, nect-lkg. (*b*) *Muscidae*: 4. Sapromyza rosida *Fall.*, nect-lkg.

MacLeod observed an Empid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 162).

In Dumfriesshire an Empid, several other Dipters, and a wasp, have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 26).

460. M. muscosa L. (Herm. Müller, 'Alpenblumen,' pp. 187–8; Schulz, 'Beiträge,' II, pp. 45–6.)—This species bears protandrous hover-fly flowers. There are eight stamens, of which the four outer ones first raise themselves and open their anthers, then the four inner stamens do the same, and when all eight have withered the styles and stigmas develop. Self-pollination is, therefore, only occasionally possible (see Fig. 54). Schulz says that besides hermaphrodite flowers there are also female ones on gynodioecious, more rarely on gynomonoecious plants.

Visitors.—Herm. Müller frequently observed small hover-flies—especially Sphegina clunipes *Fall.*—which hover in front of a flower, alight to lick nectar or devour pollen, and then go off to another. A. Schulz noticed small bees as well as flies.

133. Krascheninikovia Turcz.

Kuhn states that cleistogamous flowers occur in this genus.

134. Arenaria L.

Flowers small and white, homogamous or protandrous, with half-concealed nectar secreted in the usual place.

461. A. serpyllifolia L. (Herm. Müller, 'Weit. Beob.,' II, p. 226; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 161; Kirchner, 'Flora v. Stuttgart,' p. 754; Schulz, 'Beiträge,' I, p. 19, II, p. 47.)—In this species the stamens and stigmas mature simultaneously, and in sunshiny weather drops of nectar can be seen in the base of the flower. Schulz also observed female flowers on gynomonoecious, rarely on gynodioecious plants. In hermaphrodite flowers the stamens are frequently reduced in number; and automatic self-pollination by contact of stigmas and anthers is unavoidable.

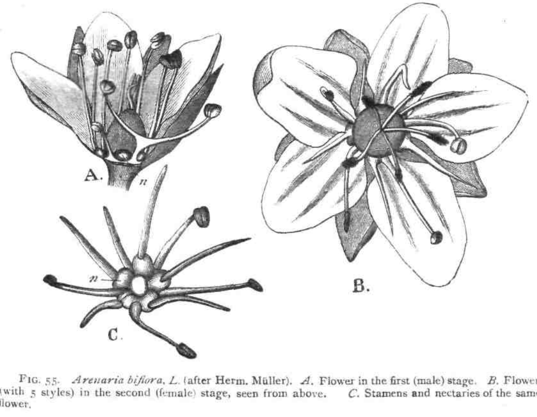

FIG. 55. *Arenaria biflora, L.* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Flower (with 5 styles) in the second (female) stage, seen from above. *C.* Stamens and nectaries of the same flower.

VISITORS.—Herm. Müller observed 2 small short-tongued bees—Sphecodes ephippius *L.* ♀, and Halictus lucidulus *Schenck* ♀, skg.—both capable of effecting cross-pollination.

MacLeod saw a hover-fly in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 377).

In Dumfriesshire, a hover-fly and Thrips have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 26).

462. A. biflora L. (Herm. Müller, 'Alpenblumen,' pp. 185–7; Schulz, 'Beiträge,' II, pp. 47–8.)—The white flowers are protandrous, but the periods of maturation, not only of the outer and inner stamens, but also of the inner stamens

and the stigmas, are not sharply demarcated. Failing insect-visits, automatic self-pollination therefore takes place (see Fig. 55). Besides hermaphrodite flowers, Schulz also observed female ones on gynodioecious, rarely on gynomonoecious plants.

VISITORS.—In the Alps, Herm. Müller only saw Diptera, i. e. 11 Muscidae, 3 Syrphidae, and an Empid.

463. **A. ciliata** L.—Kirchner examined the hermaphrodite flowers at Zermatt ('Beiträge,' p. 14).

They are protandrous, and when fully expanded their diameter is 12 mm. After the anthers have dehisced, the styles develop and the stigmatic papillae mature. Besides hermaphrodite flowers, Kirchner also observed smaller female ones with a diameter of 7–10 mm. The stamens of these are in various stages of reduction: though all ten are sometimes present, all or most of them are quite short, while some of them may be entirely absent. Ludwig (Bot. Centralbl., Cassel, iii, 1880, p. 1021) first noticed the occurrence of female flowers on gynodioecious plants in Switzerland; Warming found the species to be gynomonoecious in Norway ('Om Caryophyll. blomst.,' 1890, pp. 32–3).

Warming saw ripe fruits at Disko on the variety (*b*) *humifusa* Rink, the flowers being slightly protandrous at first and afterwards homogamous.

According to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 64), the variety *frigida* Koch flowers in Spitzbergen from the beginning of July till August. Ekstam observed ripe fruits on August 7, 1897 ('Blütenbiol. Beob. a. Spitzbergen,' p. 28). The pollen-grains are of two sizes; in one case there was 23% of small grains. The flowers are very fragrant; Ekstam gives their diameter as 11–14 mm. In flowers not fully open the stigmas already possess glistening papillae, while the anthers are still undehisced. When the flowers are quite expanded autogamy takes place, for the dehiscing anthers come into contact with the stigmas by bending of the filaments. Nectar is secreted on the outer sides of the stamens superposed to the sepals.

VISITORS.—On one occasion Ekstam observed a small fly in Spitzbergen.

464. **A. graminifolia** Schrad.—

VISITORS.—Loew observed a Syrphid—Eristalis nemorum *L.*—and two bees—Apis mellifica *L.* ☿, skg., and Prosopis communis *Nyl.* ♂, po-dvg.—in the Berlin Botanic Garden.

465. **A. arctica** Stev.—This species is native to Siberia and Alaska. According to Alice Eastwood (Bot. Gaz., Chicago (Ill.), xxxiii, 1902, pp. 137–8), the petals are over 7 mm. long and 5 mm. wide, with short yellow claws. The filaments thicken abruptly at their bases, so that there is perhaps a secretion of nectar.

135. Holosteum L.

Flowers homogamous, slightly protandrous or protogynous flowers, with half-concealed nectar.

466. **H. umbellatum.** (Herm. Müller, 'Weit. Beob.,' II, pp. 226–7; Schulz, 'Beiträge,' II, pp. 48–9; Warnstorf, Verh. natw. Ver., Berlin, xxxviii, 1896; Schr. natw. Ver., Wernigerode, xi, 1896.)—According to Herm. Müller, the small white flowers are protandrous, and cross-pollinated by insect-visits, though automatic self-

pollination can take place early. There are usually only three stamens, more rarely five, four, or two. A green fleshy nectary is situated at the base of each stamen. At the beginning of anthesis, when the anthers are dehiscing, the styles with their incompletely developed stigmas are erect. The stamens, however, are so curved inwards as to bring the anthers immediately above the stigmas, so that when these are mature automatic self-pollination must result from the fall of pollen. It also often takes place in the closed flower. Dehisced stamens gradually incline outwards, and the stigmas spread out more and more. Warnstorf says that the outer stamens ripen earlier than the inner ones; their filaments are longer, and their bases are provided with yellow nectaries. The anthers are yellow, and after dehiscence undergo a rotation through 90°, so as to become horizontal. The pollen-grains are golden yellow, regularly dodecahedral, and closely beset with short spines; average diameter 37 μ.

Besides hermaphrodite flowers, female ones have also been observed, distributed gynodioeciously, or more rarely gynomonoeciously. The ordinary flowers are locally—e. g. in Denmark—homogamous, or even protogynous.

VISITORS. — Herm. Müller observed a Muscid—Anthomyia sp. ♀ — and 3 bees, i. e. Andrena gwynana *K.* ♀, skg.; A. parvula *K.* ♀, skg.; and Halictus sp. ♀, skg.

136. Stellaria L.

Flowers white, protandrous, homogamous, or protogynous, with half-concealed nectar secreted at the bases of the stamens.

467. S. graminea L. (Herm. Müller, 'Fertilisation,' pp. 133–4, 'Weit. Beob.,' II, p. 227; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 45, 'Bloemenbiol. Bijdragen'; Kirchner, 'Flora v. Stuttgart,' p. 238; Ludwig, Bot. Centralbl., Cassel, iii, 1880; Schulz, 'Beiträge,' I, p. 20, II, pp. 50–1.)—In this species the five nectaries are in the form of green, fleshy ridges at the bases of the five outer stamens. The flowers are

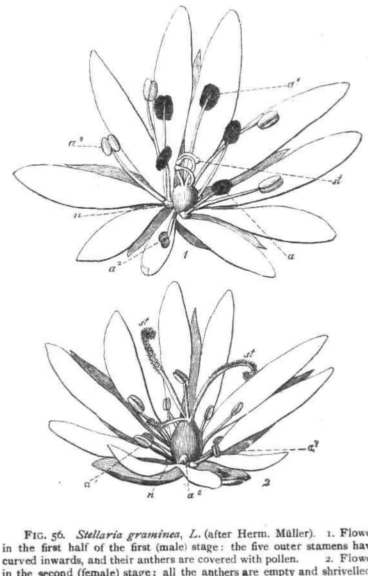

FIG. 56. *Stellaria graminea, L.* (after Herm. Müller). 1. Flower in the first half of the first (male) stage: the five outer stamens have curved inwards, and their anthers are covered with pollen. 2. Flower in the second (female) stage: all the anthers are empty and shrivelled; the styles have spread out and curved backwards, thus turning upwards their papillose sides. a^1 and a^2, outer and inner stamens; *n*, nectaries; *st*, stigmas.

protandrous, and when they open the five outer stamens first bend inwards and dehisce, the five inner ones being as yet unripe and curved outwards, and the stigmas immature. Before the anthers of the five outer stamens have withered, those of the five inner ones dehisce, but still remain directed outwards. As they wither, the styles elongate, and the stigmas unfold above the contracting and shrivelling stamens. Every insect that is not too small must, therefore, when trying to get at the nectar, dust itself with pollen in the younger flowers, whether it alights in the middle or at the edge; while in older flowers it is obliged to touch the stigmatic papillae, thus effecting cross-pollination. Failing insect-visits, the stigmatic branches bend back still more, coming into contact with the anthers to which pollen still adheres, and in this way automatic self-pollination takes place as a last resource (see Fig. 56).

Besides these protandrous hermaphrodite flowers, the mechanism of which has been thus described by Hermann Müller, there are small female ones, with quite vestigial stamens of white colour, and also medium-sized transitional forms, with 2–3 stamens developed (e.g. in Belgium, according to MacLeod). The plant is gynodioecious in Sweden (Tullberg), and by the Altenfjord (Warming). Schulz observed gynomonoecism, as well as gynodioecism, in Central Germany, where in some localities the stocks may be mainly or exclusively female. He noticed hermaphrodite flowers of three different sizes, i.e. 8–10 mm., 10–14 mm., and 16–18 mm. in diameter. These seem to be local. The larger flowers are not visited by more numerous insects than the smaller ones.

VISITORS.—Schulz observed flies, small bees, and beetles. In the Alps, where *Lepidoptera* abound, Herm. Müller saw a butterfly. He (H. M.) and myself (Kn.) have observed the following in North and Central Germany:—**A. Coleoptera.** *Nitidulidae*: 1. Meligethes, skg. and po-dvg. (H. M.). **B. Diptera.** (*a*) *Empidae*: 2. Empis livida *L.*, skg. (H. M.). (*b*) *Syrphidae*: 3. Eristalis tenax *L.*, skg. (Kn.); 4. Helophilus pendulus *L.*, skg. (Kn.); 5. Syritta pipiens *L.*, skg. and po-dvg. (H. M.); 6. Volucella bombylans *L.*, skg. (H. M.).

Verhoeff saw the following in Norderney.—**A. Coleoptera.** (*a*) *Nitidulidae*: 1. Brachypterus gravidus *Ill.*, skg. **B. Diptera.** (*a*) *Empidae*: 2. Hilara quadrivittata *Mg.*, skg. (*b*) *Muscidae*: 3. Anthomyia sp. (*c*) *Syrphidae*: 4. Melanostoma mellina *L.*, skg.; 5. Syritta pipiens *L.*, skg. **C. Hymenoptera.** (*a*) *Formicidae*: 6. Lasius niger *L.*, skg.

MacLeod noticed Apis, 6 Syrphids, an Empid, 2 ichneumon-flies, a Siricid, and a Lepidopterid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 164).

In Dumfriesshire, an Empid, 2 hover-flies, and 4 Dolichopidae have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 29).

468. S. cerastioides L. (Herm. Müller, 'Alpenblumen,' pp. 188–9.)—The number of carpels is variable in the homogamous flowers of this species.

VISITORS.—Herm. Müller saw Diptera (an Empid, 2 Muscidae, and 4 Syrphidae) in the Alps.

469. S. Holostea L. (Herm. Müller, 'Fertilisation,' p. 135; 'Weit. Beob.,' II, p. 228; Kirchner, 'Flora v. Stuttgart,' p. 238; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 378; vi, 1894, pp. 162–3; Schulz, 'Beiträge,' I, p. 22; Knuth, 'Bloemenbiol. Bijdragen.')

Hermann Müller states that the flower mechanism of this species agrees in the main with that of S. graminea, but the flowers are larger, and insect visitors are consequently more numerous. The nectaries are yellow. During anthesis, the five outer and the five inner stamens successively occupy the middle of the flower, those which are not dehiscing being curved outwards. Besides hermaphrodite flowers, female ones have been observed, and also transitional forms; e.g. MacLeod—in Belgium—noticed flowers with partly reduced stamens. Schulz states that the female blossoms are distributed gynodioeciously, or more rarely gynomonoeciously. In addition to the protandrous hermaphrodite flowers, Schulz describes homogamous ones in which automatic self-pollination is inevitable.

Visitors.—Herm. Müller (H. M.), Borgstette (B.), Buddeberg (Budd.), and myself (Kn.) have observed the following in Central and North Germany.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes, freq., skg. (H. M., Kn.). (*b*) *Oedemeridae*: 2. Oedemera virescens *L.* (B.). **B. Diptera.** (*a*) *Bombyliidae*: 3. Bombylius canescens *Mik.*, skg. (Budd.); 4. B. major *L.*, skg. (Kn.). (*b*) *Empidae*: 5. Empis ciliata *F.* ♀, skg. and po-dvg. (Budd.); 6. E. opaca *F.*, skg. (H. M.); 7. E. tessellata *F.*, skg. (H. M.). (*c*) *Muscidae*: 8. Anthomyia sp., skg. (H. M.); 9. Hydrotaea dentipes *F.*, skg. (H. M.); 10. Scatophaga merdaria *L.*. skg. (Kn.); 11. Siphona geniculata *Deg.*, skg. (H. M.). (*d*) *Syrphidae*: 12. Eristalis arbustorum *L.*, skg. and po-dvg. (H. M.); 13. E. nemorum *L.*, ditto (Kn.); 14. Platycheirus peltatus *Mg.*, ditto (H. M.); 15. Rhingia rostrata *L.*, ditto (Kn.); 16. Syrphus balteatus *Deg.*, ditto (Kn.); 17. S. ribesii *L.*, freq., ditto (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 18. Andrena cineraria *L.* ♀, skg. (H. M., Budd.); 19. A. parvula *K.* ♀, skg. (H. M.); 20. A. gwynana *K.* ♀. skg. (H. M.); 21. A. labiata *Schenck et Nyl.* ♀, skg. (Budd.); 22. Apis mellifica *L.* ☿, skg. (H. M., Kn.); 23. Halictus cylindricus *F.* ♀, skg. (H. M., Budd., Kn.); 24. H. albipes *K.* ♀, skg. and po-cltg. (Budd.); 25. H. flavipes *F.* ♀, skg. (Budd.); 26. H. nitidiusculus *K.* ♀, skg. (Budd.); 27. H. rubicundus *Chr.* ♀, skg. (Budd.); 28. Nomada flavoguttata *K.* ♀, skg. (H. M., Budd.); 29. N. ruficornis *L.* ♀, skg. (H. M., Budd.). (*b*) *Tenthredinidae*: 30. Cephus pallipes *Kl.*, skg. (H. M.). **D. Lepidoptera.** *Rhopalocera*: 31. Pieris napi *L.*, skg. (H. M.); 32. P. rapae *L.*, skg. (H. M.). **E. Thysanoptera.** 33. Thrips, freq. (H. M.).

Alfken noticed the following at Bremen.—**A. Hymenoptera.** *Apidae*: 1. Andrena chrysopyga *Schenck* ♀, skg.; 2. Nomada bifida *Ths.*, skg.; 3. N. flavoguttata *K.* ♀ and ♂, skg. **B. Diptera.** *Syrphidae*: 4. Platycheirus albimanus *F.*

Schenck saw the bee Andrena cingulata *F.* in Nassau, and Rössler the moth Asychna modestella *Dup.* at Wiesbaden.

MacLeod observed 6 hover-flies, 12 other Diptera, 2 beetles, and 3 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 162–3); a bee, 3 Syrphidae, and 4 Muscidae in the Pyrenees (op. cit., iii, 1891, p. 378).

In Dumfriesshire, several flies, Meligethes, and another beetle have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 30).

Burkill ('Fertlsn. of Spring Flowers') noticed a Muscid—Sepsis nigripes *Mg.*—on the coast of Yorkshire.

470. S. scapigera Willd.—Breitenbach found this species to be gynodimorphous in the Marburg Botanic Garden and Göttingen (Kosmos, Stuttgart, xiv, 1884).

471. S. media Cyrill. (Herm. Müller, 'Fertilisation,' pp. 135–6; 'Weit. Beob.,' II, p. 228; Schulz, 'Beiträge,' I, p. 20; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 45, 151; 'Bloemenbiol. Bijdragen'; Kirchner, 'Flora v. Stuttgart,' p. 237;

Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Hermann Müller states that some of the ten stamens are almost always vestigial, these being usually the inner five, and often one or two of the outer whorl in addition. The nectaries are situated on the bases of the five outer stamens, and secrete during sunny weather. The anthers dehisce successively, either simultaneously with the maturation of the stigmas, or somewhat earlier, or rather later. According to Kerner, autogamy takes place when the flowers begin to close. Warnstorf says that at Ruppin the plant bears either hermaphrodite flowers or pseudo-hermaphrodite fruiting flowers. The former possess two to five, or more rarely six to eight stamens, which have violet anthers projecting beyond the stigmas or at the same level, and effect autogamy by moving inwards. In the pseudo-hermaphrodite fruiting flowers all or some of the stamens have degenerated. The variety *decandra* is markedly protandrous. Automatic self-pollination takes place when the flowers close, and results in autocarpy. According to Anna Bateson, plants produced by crossing are somewhat larger and heavier than those resulting from autocarpy in the proportion of 100 : 91; Čelakovsky states that the variety *boraeana* is cleistogamous.

In Greenland, according to Warming, the hermaphrodite flowers agree in their mechanism with those of Europe, and there are also female ones, distributed gynodioeciously or gynomonoeciously. Cleistogamy obtains in the same country.

Plants observed by Vanhöffen in Greenland (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' p. 20), and by Andersson and Hesselman in Spitzbergen ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 86), were sterile, like several other introduced weeds.

This species flowers so early that it has few rivals, and occurs in such numbers that visitors are moderately numerous in spite of the smallness of its flowers. In the hermaphrodite blossoms these may effect either cross- or self-pollination.

Visitors.—Hermann Müller (H. M.) in Westphalia and myself (Kn.) in Schleswig-Holstein have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., skg. (H. M.); 2. Chlorops circumdata *Mg.*, industriously skg. (H. M.); 3. Lucilia cornicina *F.*, po-dvg. (Kn.); 4. Musca corvina *F.*, ditto (H. M.); 5. M. domestica *L.*, ditto (H. M., Kn.); 6. Pollenia rudis *F.*, po-dvg. (Kn.); 7. Scatophaga sp., po-dvg. (Kn.); 8. Sepsis sp., skg. (H. M.). (*b*) *Syrphidae*: 9. Ascia podagrica *F.*, skg. (H. M.); 10. Cheilosia sp., skg. (H. M.); 11. Eristalis arbustorum, *L.*, po-dvg. (Kn.); 12. Syritta pipiens *L.*, skg. and po-dvg. (H. M., Kn.); 13. Syrphus corollae *F.*, po-dvg. (Kn.); 14. S. ribesii *L.*, po-dvg. (Kn.). **B. Hymenoptera.** (*a*) *Apidae*: 15. Andrena albicans *Müll.* ♀, skg. (H. M); 16. A. albicrus *K.* ♂, skg. (H. M.); 17. A. chrysosceles *K.* ♂, skg. (H. M.); 18. A. dorsata *K.* ♀, skg. (H. M.); 19. A. fasciata *Wesm.* ♂, skg. (H. M.); 20. A. florea ♀ and ♂, skg. (H. M.); 21. A. fulvicrus *K.* ♂, skg. (H. M.); 22. A. gwynana *K.* ♀, skg. and po-cltg. (H. M.); 23. A. smithella *K.* ♂, skg. (H. M.); 24. Apis mellifica *L.* ☿, skg. (Kn.); 25. Halictus cylindricus *F.*, skg. (Kn.); 26. H. flavipes *F.* ♀, skg. (H. M., Kn.); 27. H. leucopus *K.* ♀, skg. (H. M.); 28. H. sexstrigatus *Schenck* ♀, skg. (H. M.); 29. Osmia rufa *L.* ♂, skg. (H. M.); 30. Sphecodes gibbus *L.* ♀, skg. (H. M.). (*b*) *Cynipidae*: 31. Eucoela sp. (H. M.). **C. Thysanoptera.** 32. Thrips, po-dvg. (H. M.).

MacLeod noticed Apis, 14 other short-tongued Hymenoptera, 7 Syrphidae, 10 other Diptera, and 2 beetles in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894. pp. 166–7).

Verhoeff observed the following in Norway.—

A. Diptera. (*a*) *Bibionidae*: 1. Scatopse notata *L.* (*b*) *Muscidae*: 2. Anthomyia sp., freq., skg.; 3. Lucilia caesar *L.* ♀ and ♂, skg.; 4. Nemopoda stercoraria *Rob.-Desv.*, skg. (*c*) *Syrphidae*: 5. Platycheirus clypeatus *Mg.* ♂, skg.; 6. Syritta pipiens *L.*, skg. **B. Hymenoptera.** *Formicidae*: 7. Lasius niger *L.*, skg.

Alfken saw the following at Bremen.—

A. Hymenoptera. *Apidae*: 1. Andrena parvula *K.* ♀, skg.; 2. Halictus nitidiusculus *K.* ♀, skg.; 3. Podalirius acervorum *L.* ♂. **B. Diptera.** *Syrphidae*: 4. Chrysogaster macquarti *Loew.*

Bees have also been recorded as follows.—By Schmiedeknecht in Thuringia—1. Andrena congruens *Schmiedekn.*; 2. A. dorsata *K.* ♂; 3. A. eximia *Sm.*; 4. A. floricola *Ev.*

By Friese in Baden (B.) and Mecklenburg (M.)—1. Andrena gwynana *K.*, 2nd generation (M.); 2. A. parvula *K.*, freq. (M.), very freq. (B.).

By von Dalla Torre and Schletterer in the Tyrol—1. Andrena eximia *Sm.* ♂; 2. Halictus albipes *Fbr.* ♀; 3. Nomada alternata *K.* ♂.

Burkill observed the following—all skg.—on the Yorkshire coast ('Fertlsn. of Spring Flowers').—

A. Diptera. (*a*) *Bibionidae*: 1. Scatopse notata *L.* (*b*) *Muscidae*: 2. Lucilia cornicina *F.*; 3. Phorbia muscaria *Mg.*; 4. Scatophaga stercoraria *L.*; 5. Sepsis nigripes *Mg.* (*c*) *Phoridae*: 6. Phora, sp. **C. Hymenoptera.** *Ichneumonidae*: 7. Pezomachus, sp. **C. Thysanoptera.** 8. Thrips, sp.

In Dumfriesshire—Meligethes and numerous Diptera have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 28).

472. **S. nemorum** L.—The hermaphrodite flowers of this species are everywhere more or less distinctly protandrous. Besides these there are smaller female ones, distributed gynodioeciously in Thuringia (Ludwig) and the Riesengebirge (Schulz) or more rarely gynomonoeciously.

Visitors.—Lindman observed small and medium-sized flies on the Dovrefjeld.

In Dumfriesshire—Meligethes and numerous flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 28).

473. **S. Frieseana** Lange.—Lindman states that the variety *alpestris* is protogynous on the Dovrefjeld, becoming homogamous later on by persistence of the stigmas. In Atnedal, however, there are also many protandrous plants. Automatic self-pollination easily takes place towards the end of anthesis, by the contact of stigmas and anthers.

474. **S. palustris** Ehrh. (= S. glauca *With.*).—In this species gynodioeciously distributed female flowers have been observed in Denmark (Warming) and Germany (Ludwig, Hermann Müller), as well as strongly protandrous hermaphrodite ones.

Visitors.—MacLeod observed a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 164).

475. **S. bulbosa** Wulf.—Kerner made observations on this species in Carniola. The flowers are moderately large, and yet receive very few visits from insects (some flies), and are quite infertile. Propagation is effected by means of numerous little tubers on the thread-like underground stem.

476. S. crassifolia Ehrh.—In Denmark, Warming observed gynodioeciously distributed female flowers in addition to the markedly protandrous hermaphrodite ones. Warnstorf describes the flowers at Ruppin as being also protandrous.

477. S. longipes Goldie.—Warming states that the hermaphrodite flowers of this species are protandrous or homogamous in Greenland, while self-pollination appears to be prevented by the distance between anthers and stigmas. The female flowers are gynodioeciously distributed, as also in Spitzbergen, where, however, they are remarkably small.

Ekstam describes the flowers in Nova Zemlia as odourless, protogynous-homogamous, and 8–12 mm. in diameter. In Spitzbergen and Greenland, according to Warming, the hermaphrodite flowers are protandrous-homogamous, or homogamous, and there are also purely female ones.

Andersson and Hesselman state (*'Bidrag till Känned. om Spetsbergens o. Beeren* Eil. Kärlväxtflora,' p. 56) that this species flowers in Spitzbergen from the middle of July till the end of August, and ripens its fruits. Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' pp. 25–6) gives the diameter of the flowers of the variety *humilis* Fenzl as 8–12 mm., and he noticed some instances of apetaly. The sexual organs mature simultaneously after the flowers have opened, and autogamy is rendered possible by bending of the stamens towards the stigmas. The floral receptacle obviously secretes nectar between the bases of the stamens.

In Greenland this extremely variable plant is so abundant that it serves as food for reindeer (Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' pp. 21–2).

Visitors.—On four different days Ekstam noticed several small Diptera in Spitzbergen, and he observed a medium-sized fly in Nova Zemlia.

478. S. humifusa Rottb.—In Greenland, according to Warming, the hermaphrodite flowers of this species are usually protandrous, rarely protogynous, but in later stages they are always homogamous. The female flowers are distributed in Spitzbergen like those of the last species. Warming saw no fruits, and there is probably a large amount of vegetative propagation by means of buds.

For Nova Zemlia Ekstam gives the diameter of the protogynous-homogamous flowers as 10–15 mm. Self-pollination is possible. There is sometimes a tolerably strong odour of honey, associated with the secretion of a considerable quantity of nectar.

According to Andersson and Hesselman (op. cit., p. 56), this species flowers in Spitzbergen from the middle of July to the end of August, and ripens fruits. Ekstam (op. cit., p. 26) gives the diameter of the flowers as 6–8 mm.; in Greenland it is 8–10 mm., according to Abromeit (op. cit., p. 20). Ekstam observed slight protandry.

Visitors.—Ekstam observed a small fly in Nova Zemlia.

479. S. borealis Bigel.—Lindman states that the flowers of this species are homogamous on the Dovrefjeld. Towards the end of anthesis the anthers of the longer stamens come into contact with the stigmas, and self-pollinate them. In Greenland, according to Warming, the flowers are apetalous, homogamous, and automatically self-pollinated. Gynodioecism has also been observed.

480. S. uliginosa Murr. (MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 164–5; Knuth, 'Blütenbiol. Beob. a. d. nordfr. Ins.,' p. 145; Schulz, 'Beiträge,' I, pp. 22–3.)—MacLeod describes plants of this species in Belgium as possessing inconspicuous protandrous flowers, with petals shorter than the sepals. The outer stamens first mature, and remain in the middle of the flower during the whole period of anthesis, while the inner ones curve outwards. After dehiscence, the styles develop, and the spreading stigmas come into contact with the outer anthers. Towards the end of anthesis the outer stamens, in contact with the stigmas, also incline inwards, so that automatic self-pollination is always assured.

The flowers are more or less protandrous in Denmark (Warming) and at Halle, but they are homogamous during autumn in the latter locality (Schulz). Schulz found them to be commonly homogamous and automatically self-pollinated in the Riesengebirge. Besides hermaphrodite flowers, this observer also noticed female ones, distributed gynodioeciously, or more rarely gynomonoeciously.

VISITORS.—MacLeod observed an Empid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 165).

In Dumfriesshire, several flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 29).

137. Moenchia Ehrh.

Small white protogynous flowers, with half-concealed nectar.

481. M. erecta Gaertn. Mey. et Scherb.—According to Schulz ('Beiträge,' II, p. 51), some of the stamens in this species are usually not developed. Even in the bud the four (more rarely three or five) stigmas are receptive. When the flowers are open the stigmas but rarely come into contact with the anthers: automatic self-pollination is therefore not very likely to occur. In dull weather, however, effective autogamy takes place in pseudo-cleistogamous closed flowers. During bright sunshine nectar is secreted in tolerable abundance.

VISITORS.—Schulz only saw a few flies.

138. Malachium Fries.

Flowers white, protandrous, with half-concealed nectar.

482. M. aquaticum L. (=Cerastium aquaticum *L.*). (Herm. Müller, 'Fertilisation,' p. 133, 'Weit. Beob.,' II, p. 230; Knuth, 'Bloemenbiol. Bijdragen'; Kirchner, 'Flora v. Stuttgart,' p. 239; Schulz, 'Beiträge,' I, p. 23; Ludwig, D. bot. Monatschr., Arnstadt, vi, 1888, p. 5, Bot. Centralbl., Cassel, viii, 1881, p. 79; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Hermann Müller states that the mechanism of the protandrous flowers resembles that of Stellaria Holostea. The petals are about $1\frac{1}{2}$ times as long as the sepals. Should insect-visits fail, the ends of the spreading (3–5) stigmatic branches regularly come into contact with the pale anthers, to which pollen still remains clinging. According to Schulz, self-pollination is very rare; while Kerner has observed that it occurs towards the end of anthesis, at the time when the flowers begin to close. Gynodioecism has been observed (Ludwig), rarely gynomonoecism (Schulz); but not in Denmark, according to Warming. The petals of the female flowers are

only as long as the sepals, and their stamens possess yellow degenerate anthers. Warnstorf usually found only hermaphrodite flowers at Ruppin, 1–4 stamens being vestigial in rare instances. The five outer stamens bend over the stigmatic branches, and discharge their pollen when these are still closely apposed. Meanwhile the inner stamens—with anthers as yet immature—lie remote from the centre between the petals, and only dehisce when the stigmatic branches begin to spread out. After dehiscence the inner stamens curve back again, so that all the anthers are in a peripheral circle when the stigmatic branches have fully diverged. Self-pollination is thus rendered very difficult. The pollen clings to the anthers for a time. The pollen-grains are white, dodecahedral and smooth, with an average diameter of 37–43 μ.

VISITORS.—Hermann Müller (H. M.) in Westphalia, Buddeberg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes, freq., nect-lkg. (H. M.). **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia, skg. (H. M.). (*b*) *Syrphidae*: 3. Ascia podagrica *F.*, freq., skg. (H. M.); 4. Eristalis arbustorum *L.*, skg. and po-dvg. (H.M., Kn.); 5. Helophilus lineatus *F.*, freq., skg. (H. M.); 6. Rhingia rostrata *L.*, skg. and po-dvg. (Kn.); 7. Syritta pipiens *L.*, ditto (H. M., Kn.); 8. Syrphus sp., ditto (Kn.). **C. Hymenoptera.** *Apidae*: 9. Colletes daviesanus *K.* ♂, skg. (Budd.); 10. Halictus quadricinctus *F.* ♀, skg. (H. M.); 11. H. sexnotatus *K.* ♂, skg. (H. M.); 12. Prosopis communis *Nyl.* ♀, skg. (H. M.); 13. P. hyalinata *Sm.* ♀, skg. (H. M.). **D. Thysanoptera.** 14. Thrips, very freq. (H. M.).

MacLeod saw a short-tongued bee in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 378), as well as 3 hover-flies and 3 other Diptera (op. cit., vi, 1894, p. 170).

139. Cerastium L.

Flowers mostly white and protandrous, with half-concealed nectar secreted as in the preceding genera.

483. C. arvense L. (Herm. Müller, 'Fertilisation,' pp. 131–2, 'Weit. Beob.,' II, p. 229; Schulz, 'Beiträge,' I, p. 24; Kirchner, 'Flora v. Stuttgart,' p. 240; Knuth, 'Bloemenbiol. Bijdragen'; Loew, 'Blütenbiol. Floristik,' pp. 389, 397; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The flowers of this species are protandrous, and, according to Hermann Müller, agree with *Stellaria Holostea* as regards the position of the nectaries, and the order of maturation of stamens and stigmas. There is, therefore, an agreement as to the probability of cross-pollination by insect-visits, and the possibility of self-pollination when such visits fail. The plants examined by Warming in Greenland, as far north as 67° N. lat., had somewhat smaller protandrous flowers.

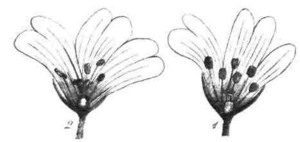

FIG. 57. *Cerastium arvense*, *L.* (after Herm. Müller). (1) Flower in the first part of the first (male) stage: the anthers of the outer stamens are covered with pollen, those of the inner ones are still closed, and the stigmatic branches are still curved inwards. (2) Flower in the almost exclusively female stage; the anthers of the outer stamens have partly fallen off, partly shrivelled; those of the inner whorl are still sparingly covered with pollen; the stigmas are mature.

Besides the hermaphrodite flowers, smaller female ones with degenerate whitish stamens have been observed. Schulz states that their distribution is usually

gynodioecious, more rarely gynomonoecious. At Ruppin, according to Warnstorf, there are hermaphrodite flowers of two sizes, respectively 15 mm. and 10 mm. in diameter. The small-flowered variety is further characterized by the possession of glandular hairs on the stem, especially on the upper part of this.

VISITORS.—Herm. Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Coleoptera. (*a*) *Carabidae*: 1. Amara sp. (H. M.). (*b*) *Cerambycidae*: 2. Leptura livida *F.*, vainly searching for nectar (H. M.); 3. Malachius bipustulatus *F.* (H. M.). (*c*) *Nitidulidae*: 4. Meligethes, nect-lkg. (H. M., Kn.). (*d*) *Staphylinidae*: 5. Omalium florale *Payk.* (H. M.). (*e*) *Telephoridae*: 6. Dasytes sp., po-dvg. (H. M.). **B. Diptera.** (*a*) *Conopidae*: 7. Dalmannia punctata *F.*, skg. (H. M.). (*b*) *Empidae*: 8. Empis livida *L.*, skg. (H. M.); 9. E. opaca *F.*, very freq., skg. (H. M.); 10. E. rustica *Fall.*, ditto (H. M.). (*c*) *Leptidae*: 11. Leptis strigosa *Mg.*, skg. (H. M.). (*d*) *Muscidae*: 12. Anthomyia aestiva *Mg.*, skg. (H.M.); 13. Onesia sepulcralis *Mg.*, skg. (H. M.); 14. Pyrellia aenea *Zett.*, po-dvg. (H. M.); 15. Scatophaga merdaria *F.*, skg. (H. M.); 16. S. stercoraria *L.*, skg. (Kn.). (*e*) *Syrphidae*: 17. Eristalis arbustorum *L.*, skg. (H. M., Kn.). 18. E. nemorum *L.*, skg. (H. M., Kn.); 19. E. sepulcralis *L.*, skg. (H. M.); 20. Helophilus sp., skg. (Kn.); 21. Melanostoma mellina *L.*, freq., skg. (H. M., Kn.); 22. Melithreptus scriptus *L.*, skg. (H. M.); 23. M. strigatus *Staeg.*, po-dvg. (H. M.); 24. Platycheirus manicatus *Mg.*, freq., skg. (H. M.); 25. Syritta pipiens *L.*, skg. (H. M., Kn.): 26. Syrphus pyrastri *L.*, skg. (Kn.); 27. S. sp., skg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 28. Andrena albicans *Müll.* ♀, skg. (H. M.); 29. A. argentata *Sm.* ♀, skg. (H. M.); 30. A. cineraria *L.* ♀, skg. (H. M.); 31. Halictus leucozonius *Schr.* ♀, skg. (H. M.); 32. H. sexnotatus *K.* ♀, in large numbers, skg. (Kn.); 33. H. sp. ♀, skg. (H. M.). (*b*) *Ichneumonidae*: 34. Ichneumon sp., skg. (H. M.). **D. Lepidoptera.** (*a*) *Noctuidae*: 35. Euclidia glyphica *L.*, skg. (H. M.). (*b*) *Rhopalocera*: 36. Pieris napi *L.*, skg. (Kn.); 37. Polyommatus dorilis *Hfn.*, skg. (H. M.); 38. P. phlaeas *L.*, skg. (H. M.). **E. Thysanoptera.** 39. Thrips, freq. (H. M.).

Herm. Müller saw 20 Diptera, 2 bees, and 3 Lepidoptera in the Alps ('Alpenblumen,' p. 171).

Loew noticed the following on the variety *strictum* Haencke in Switzerland ('Beiträge,' p. 57).—

A. Diptera. *Syrphidae*: 1. Melithreptus dispar *Lw.* **B. Hymenoptera.** *Apidae*: 2. Halictus cylindricus *F.* ♀, skg. **C. Lepidoptera.** *Pyralidae*: 3. Undetermined sp.

MacLeod saw a bee, an ant, 3 Syrphidae, an Empid, and 7 Muscidae in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 378), and 4 Diptera, a Lepidopterid, and a beetle in Flanders (op. cit., vi, 1894, p. 167).

In Dumfriesshire, several Diptera have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 27).

484. C. triviale Link (= C. vulgatum *L.* and C. caespitosum *Gilib.*). (Axell, 'Om Anordning. för Fanerog. Växt. Befrukt.,' pp. 16–17; Herm. Müller, 'Fertilisation,' p. 132; Kirchner, 'Flora v. Stuttgart,' p. 240; Schulz, 'Beiträge,' I, p. 24.) Hermann Müller says that the flowers have the same mechanism for pollination as those of C. arvense, but they are smaller, in accordance with which protandry is less pronounced, and the visits of insects less numerous. Failing insect-visits, automatic self-pollination takes place and is effective (Axell). The stamens of the hermaphrodite flowers are often more or less vestigial. Protogyny has been observed

by Warming in Denmark. Schulz states that—in the Riesengebirge—protandrous and protogynous flowers sometimes occur on the same plant. Besides hermaphrodite flowers, female ones have now and then been observed, distributed gynodioeciously (Ludwig), or more frequently gynomonoeciously (Schulz). Kerner describes the variety *longirostre* Wichura as protandrous, and in this also autogamy takes place when the flowers close.

VISITORS.—Herm. Müller observed several flies—Syritta pipiens *L.*, Empis livida *L.*, and Melithreptus scriptus *L.* ♂.

Verhoeff noticed the following in Norderney.—**A. Coleoptera.** *Carabidae*: 1. Amara familiaris *Duft.* **B. Diptera.** (*a*) *Empidae*: 2. Hilara quadrivittata *Mg.* ♂ and ♀, freq., skg. (*b*) *Muscidae*: 3. Anthomyia sp.; 4. Aricia incana *Wiedem.*, skg. and po-dvg.; 5. Lucilia caesar *L.*, skg. (*c*) *Syrphidae*: 6. Eristalis arbustorum *L.*; 7. Platycheirus manicatus *Mg.* one ♂.

MacLeod saw 2 bees and a fly in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 168).

Burkill ('Fertlsn. of Spring Flowers') observed the following on the coast of Yorkshire.—

A. Diptera. (*a*) *Muscidae*: 1. Helomyza sp. (*b*) *Phoridae*: 2. Phora sp., skg. **B. Thysanoptera.** 3. Thrips sp., skg.

485. **C. semidecandrum** *L.* (Herm. Müller, 'Fertilisation,' pp. 132–3, 'Weit. Beob.,' II, pp. 229–30; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 46, 151, 'Bloemenbiol. Bijdragen'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 168; Kirchner, 'Flora v. Stuttgart,' pp. 241–2.)—Hermann Müller says that the flower mechanism of this species agrees with that of the last, but the flowers are even less conspicuous, so that insect-visits are still fewer, and the protandry less distinct. The flowers may even be quite homogamous (Schulz). In the absence of visitors automatic self-pollination regularly takes place. The inner stamens are devoid of nectaries, and almost always vestigial, there being, with rare exceptions, remains of filaments only. In dull weather the flowers remain closed. Besides hermaphrodite flowers, female ones of equal size have been observed, distributed gynomonoeciously, more rarely gynodioeciously (Schulz, 'Beiträge,' I, pp. 23–4).

VISITORS:—Herm. Müller (H. M.) and myself (Kn.) have observed the following.—**A. Diptera.** (*a*) *Muscidae*: 1. Pollenia rudis *F.*, skg. (H. M.); 2. P. vespillo *F.*, skg. (H. M.). (*b*) *Syrphidae*: 3. Rhingia rostrata *L.*, skg. (H. M.). **B. Hymenoptera.** *Apidae*: 4. Apis mellifica *L.* ☿, skg. (H. M., Kn.); 5. Sphecodes ephippius *L.* ♀, busily skg. (H. M.)

MacLeod saw 2 short-tongued bees, a Lepidopterid, and a beetle in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 168).

486. **C. obscurum** Chaub. and 487. **C. pallens** F. Schultz are closely related to the last species, with which they agree, according to Schulz, as regards the flower mechanism and distribution of the sexes.

488. **C. tetrandrum** Curt.—As observed by me on the dunes of Helgoland, this species is remarkable for the variations in number of its flower-leaves. The sepals and petals are usually in fours and the stamens in fives, while there are generally four carpels, though these may be reduced to three.

The flowers, when expanded in the sun, have a diameter of 3 to 4 mm., and are as high as broad. The petals are greenish and thickened at their bases, where

a small amount of nectar seems to be secreted, for insect visitors busy themselves persistently in this region. During my frequent visits to Helgoland in 1895 and 1897, however, I was unable to find any nectar, though I examined the bases of the petals under a tolerably high magnification. The sepals, which are beset with glandular hairs, are almost as long as the petals, and help a little in the attraction of insects.

The flowers are homogamous. At first the anthers project about 1 mm. beyond the stigmas, but near the end of anthesis incline towards and dust them with pollen. This self-pollination is clearly effective, for though insect-visits are exceedingly rare all the flowers set fruits. I always found both stamens and carpels developed, and examined numerous specimens without finding a single case where either kind of sexual organ was entirely aborted. Pentamery predominated in the more vigorous plants, tetramery in the weaker ones.

An insect visitor thrusts its head into the base of the flower, and in doing so touches the anthers—which in bright weather rest on the reflexed petals—and also the simultaneously developed stigmas, which are at the same level. Hence a visit to a second blossom must effect cross-pollination. In dull weather the flowers close, so that the anthers come into direct contact with the stigmas, and automatically self-pollinate them.

In Helgoland, on June 5, 1895, I saw a hover-fly (Syritta pipiens *L.*) visiting the flowers. This observation interested me very greatly, for on the morning of the same day I noticed on the high ground of that island the same species (also Eristalis sp.) sucking nectar in the flowers of Cochlearia danica. This confirms to a certain degree the ideas to which W. J. Behrens gave expression in 1878 (Flora, Marburg, New Series, xxxvi, 1878, pp. 225–32), with regard to the oecological connexion between Cerastium tetrandrum and Cochlearia danica. The flower mechanisms of the two species agree to such an extent that Behrens thought it possible that the former might have arisen under the influence of an insular environment from Cerastium semidecandrum, mimicking Cochlearia danica, a form better adapted to attract insects. The agreement as to insect visitors appears to give to this supposition a higher degree of probability, although Syritta pipiens also visits other flowers of similar structure in Helgoland (e. g. Brassica nigra and Capsella Bursa-pastoris). This, however, appears natural, as the size of this insect is adapted to these other flowers quite as well as to Cerastium tetrandrum and Cochlearia danica.

VISITORS.—Vide supra.

489. **C. glomeratum** Thuill.—Henslow states that the flowers of this species are autogamous; they sometimes remain closed (Warming). According to Ludwig (Bot. Centralbl., Cassel, iii, 1880, p. 1021), there are female flowers, distributed gynodioeciously, as well as hermaphrodite ones. Now and then the petals are vestigial (Kirchner). According to Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896), the homogamous and autogamous flowers open only a little, or remain closed, and the introrse anthers lie upon the branches of the style. The pollen-grains are white, and roundish-dodecahedral, with six well-marked germinating processes around the equatorial zone, and a diameter of about 37 μ.

VISITORS.—Schletterer observed Halictus calceatus *Scop.* at Pola.

490. C. brachypetalum Desp.—According to Schulz ('Beiträge,' I, pp. 51–2), the number of stamens varies in this species, as in its allies. The stigmas are receptive, even before anthesis. When the flowers open, contact between stigmas and anthers very rarely, if ever, takes place. Automatic self-pollination regularly occurs, however, when they close. Besides hermaphrodite flowers, female ones have also been observed, distributed gynomonoeciously, more rarely gynodioeciously.

VISITORS.—Schulz noticed two flies. Schletterer observed the two small bees Andrena parvula *K.* and Halictus morio *F.* at Pola.

491. C. tomentosum L.—Warming observed protandry, with transitions to homogamy in cultivated plants. Automatic self-pollination takes place towards the end of anthesis.

492. C. viscosum L.—Batalin observed that in plants of this species developed from seeds the flowers of the first summer often remained closed, while open flowers were produced the following year.

493. C. trigynum Vill. (= Stellaria cerastoides *L.*). (Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; Herm. Müller, 'Alpenblumen,' pp. 188–9; Schulz,

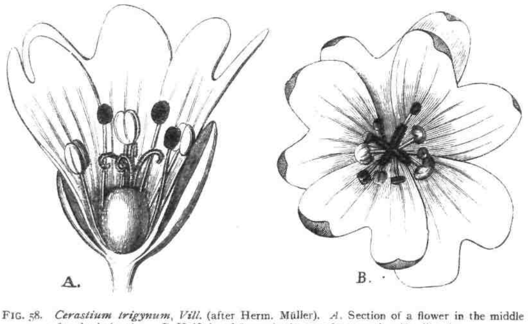

FIG. 58. *Cerastium trigynum, Vill.* (after Herm. Müller). *A.* Section of a flower in the middle of anthesis (× 7). *B.* Half-closed flower in the act of automatic self-pollination.

'Beiträge,' II, pp. 49–50.)—Hermann Müller and Ricca describe the odorous flowers as being homogamous, but Schulz says that they are sometimes slightly protogynous or protandrous. In sunny weather the anthers are so far from the stigmas that insects alighting in the middle of the flowers effect cross-pollination. In cold, dull weather the flowers hardly open at all, but in somewhat warmer cloudy weather they do so rather more. Under such circumstances automatic self-pollination always takes place. The styles vary in number from three to five. The stamens are now and then vestigial. Schulz states that the female flowers are distributed gynomonoeciously, or more rarely gynodioeciously.

On the Dovrefjeld also, according to Lindman, the flowers are homogamous and autogamous, and here self-pollination takes place at the beginning of anthesis.

Visitors.—Herm. Müller observed only Diptera—chiefly Syrphidae and Muscidae, together with some Empidae.

494. **C. latifolium** L. (Herm. Müller, 'Alpenblumen,' pp. 189–90.)—Hermann Müller describes the flowers of this species as protandrous, though A. Schulz says that they are also homogamous. Even in the former case automatic self-pollination is possible (see Fig. 59). Dovrefjeld plants are autogamous and slightly protandrous; Warming once observed slight protogyny. Kerner considers that the sticky calyx serves to protect the flowers against creeping animals. Besides hermaphrodite flowers, Schulz has observed female ones, distributed gynodioeciously, or more rarely gynomonoeciously.

Visitors.—Herm. Müller chiefly observed Diptera (8 species) in the Alps, where he also saw various bees (Halictoides), beetles (1), and Lepidoptera (4).

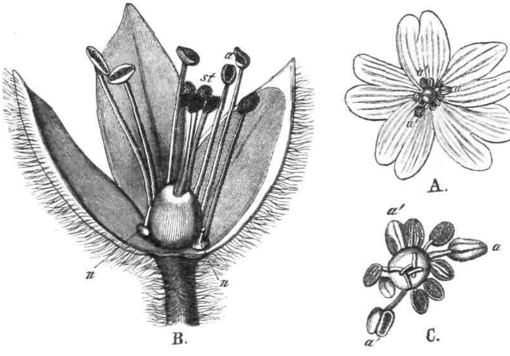

FIG. 59. *Cerastium latifolium*, L. (after Herm. Müller). *A*. Flower in the first (male) stage. *B*. Flower in the second (bi-sexual) stage (× 7). *C*. Stamens and carpels of *A* (× 7).

495. **C. alpinum** L. (=C. lanatum *Lam.*).—Besides the protandrous, ultimately homogamous hermaphrodite flowers described by Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 355), F. Ludwig observed female ones in the Alps, distributed gynodioeciously. On the Dovrefjeld the flowers are at first protandrous, and self-pollination is not effected until the stigmas bend back so as to come into contact with the anthers (Lindman). According to Warming, the flowers are also protandrous in Greenland and Spitzbergen, but to such a slight extent that homogamy and automatic self-pollination very soon obtain, sometimes even in the half-opened bud. As Warming in Greenland found the stigmas of the gynodioeciously or gynomonoeciously distributed female flowers covered with pollen, they must have been visited by insects. Ekstam gives the diameter of the protandrous-homogamous, or homogamous flowers as 10–20 mm. for Nova Zemlia. In the

larger flowers automatic self-pollination readily takes place; in the smaller it is sometimes possible. Andersson and Hesselman state that this species flowers in Spitzbergen from the middle of July till the end of August ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora'). Fruits were observed to be set, though in an irregular fashion. According to Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 26), the flowers are homogamous and 12–15 mm. in diameter. The anthers bend towards the stigmas during dehiscence, so that self-pollination easily takes place.

Visitors.—H. Müller ('Alpenblumen,' p. 190) observed Diptera (3 Muscidae and a Syrphid) and a Lepidopterid in the Alps. On the Dovrefjeld large and small Diptera and a Lepidopterid were also noticed by Lindman. Ekstam saw Diptera in Nova Zemlia, and on five occasions in Spitzbergen (large and small flies). In the latter island Holmgren observed Hymenoptera—Hemiteles septentrionalis *Holmgr.*, and Orthocentrus pedestris *Holmgr.*—as well as Diptera—Aricia (Spilogaster) dorsata *Zett.*, A. (S.) denudata *Holmgr.*, A. (S.) megastoma *Bohem.*, and Sciara atrata *Holmgr.*, very freq.

496. **C. Edmonstonii** (Wats.) Murb. et Ostenf.—Andersson and Hesselman state ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 59–61) that this species begins to flower in Spitzbergen somewhat earlier (the second half of June) than the last species, but ripens its fruits at the same time. The variety *caespitosum* Malmgr. also flowers early. The diameter of the flower varies from 9·5 to 11 mm. There are both hermaphrodite and female blossoms, the former being protogynous, homogamous, or protandrous. In all fully-developed flowers autogamy is possible by contact of the coiled reflexed stigmas with the dehisced anthers. The pollen-grains are very sensitive to damp, and at once burst when placed in distilled water. Transitional forms between hermaphrodite and female flowers are variable in number, and the latter set fruits irregularly. In one case only twelve per cent. of the last year's blossoms—of which remains were present—had done so.

497. **C. uniflorum** Murith. (= C. subacaule *Hegetschw.*, and C. glaciale *Gaud.*).—Kirchner ('Beiträge,' pp. 15–16) describes as follows the mechanism of flowers of this species—from Gorner Grat near Zermatt—which agrees in the main with that of C. latifolium.—The flowers are protandrous, but the possibility of automatic self-pollination remains. When expanded their diameter is about 15 mm.; the white petals are streaked with dark veins converging to the base of the flower; and nectar is secreted at the bases of the stamens. After anthesis the stamens diverge but little, and their anthers dehisce successively, first those of the outer, and then those of the inner ones. After the pollen is shed all the stamens curve outwards. The five styles are closely apposed in the just-opened flower, and are scarcely 2 mm. long; they elongate, however, till at the time when the five outer anthers have dehisced their length is about 5 mm. At this stage they diverge somewhat, their stigmas being receptive, and remaining so till all the stamens have shed their pollen. During anthesis, therefore, each flower passes through a male stage, then becomes hermaphrodite, and finally enters on a female condition.

XVI. ORDER *PORTULACEAE* JUSS.

140. **Portulaca** Tourn.

Small, yellow, homogamous flowers, not infrequently cleistogamous or pseudo-cleistogamous.

498. **P. oleracea** L. (Kirchner, 'Flora v. Stuttgart,' p. 254; Kerner, 'Nat. Hist. Pl.' Eng. Ed. 1, II; Battandier, Justs bot. Jahresber., Leipzig, xi (1883), 1885, p. 472; Halstead, op. cit., xvi (1888), 1890, p. 562.)—Kerner says that the golden-yellow flowers are devoid of honey and odour, and only open for about five hours on sunny mornings. Between the bases of the stamens and petals there is a fleshy ridge beset with glassy papillae. These do not secrete, but, according to Kerner, insects readily feed upon them. Stamens and stigmas mature simultaneously. Kirchner states that the latter lie between the anthers in such a way that automatic self-pollination is inevitable. Crossing, however, would appear to take place occasionally, for flies and ants have been seen as visitors. According to Kerner, automatic self-pollination only occurs when the flower closes, and also in the pseudo-cleistogamous flowers that remain shut during bad weather. Halstead describes the stamens as sensitive, and Hansgirg states that they curve in the direction of the stimulus. Cleistogamous flowers have been observed by Battandier.

499. **P. grandiflora** Lindl. — De Bonis says that this species produces cleistogamous flowers.

141. **Montia** Mich.

Small white flowers, often pseudocleistogamous.

500. **M. minor** C. C. Gmel. (Axell, 'Om Anordning. för Fanerog. Växt. Befrukt.,' p. 13; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 391.)—Axell describes the open flowers as homogamous. Both he and Kerner state that numerous flowers are pseudo-cleistogamous during bad weather, remaining closed and fertilizing themselves.

Visitors.—In Dumfriesshire, 2 Muscidae have been observed (Scott-Elliot, 'Flora of Dumfriesshire,' p. 31).

501. **M. rivularis** C. C. Gmel.—According to Vanhöffen this species flowers and fruits regularly in Greenland (see Abromeit, 'Bot. Ergeb. v. Drygalski's Grönlandsexped.,' pp. 22–3).

142. **Claytonia** Gronov.

502. **C. alsinoides** Sims.—The flowers of this species in the Cambridge Botanic Garden are protandrous, according to Willis (J. Linn. Soc. Bot., London, xxx, 1895). They secrete nectar at the bases of the filaments. The stamens are at first erect, but afterwards bend back towards the petals, giving free access to the stigma, so that small insects covered with pollen are able to effect crossing. Self-pollination is not excluded, but its effect is doubtful.

503. **C. sibirica** Pall.—Agrees with the last species (Willis, op. cit.).

504. **C. perfoliata** Donn.—According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 365), autogamy takes place towards the end of anthesis, the pollen-covered anthers being pressed against the stigma by the closing of the perianth.

143. Calandrinia H. B. et K.

When the flowers fade, the petals become pulpy, the surface being covered with a thin layer of fluid which oozes out of the tissues. This is sought out and licked by flies, which effect cross-pollination (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 171).

505. **C. compressa** Schrad.—In this species the anthers of the ephemeral blossoms are at first remote from the stigma. At a later stage they are applied to the stigma by the closing of the flower (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 346–7).

XVII. ORDER *TAMARISCINEAE* DESV.

144. Myricaria Desv.

Small red, slightly protogynous flowers, with concealed nectar, secreted by the inner sides of the filaments. All are entomophilous, according to Niedenzu (Engler and Prantl, 'D. nat. Pflanzenfam.,' III, 6, p. 290).

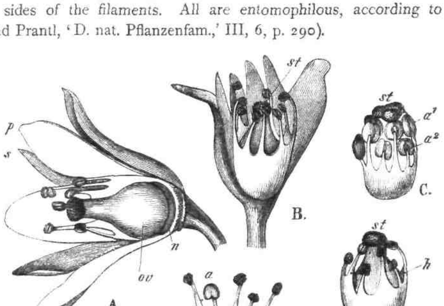

FIG. 60. *Myricaria germanica, Desv.* (after Herm. Müller). *A.* Section through an open flower; seen from the side. *B.* Section through a flower in the act of automatic self-pollination; seen from the side. *C.* Sexual organs of a bud, with stigma already receptive. *D.* Sexual organs of a flower completely closed during rain. *E.* Some of the stamens seen from within, with the nectary (*n*).

506. **M. germanica** Desv. (Herm. Müller, 'Alpenblumen,' pp. 164–5.)—In this species the stigmas are receptive, even before the flowers open, and the anthers dehisce successively soon after this takes place. The stamens and stigma both continue functional, so that in bad weather automatic self-pollination must take place in the half-closed or completely closed flower. During favourable weather insect visitors may effect crossing. (See Fig. 60.)

VISITORS.—Herm. Müller observed a fly and a Lepidopterid.

XVIII. ORDER *ELATINEAE* CAMB.

There is only one plant included in this order, of which the flowers have been studied as regards pollination.

145. Elatine L.

507. Elatine hexandra DC.—Vaucher says that automatic self-pollination takes place in the small reddish-white flowers of this species, the anthers dehiscing introrsely, and shedding pollen directly upon the three stigmas.

XIX. ORDER *HYPERICINEAE* DC.

This order is represented by the genus

146. Hypericum L.

The flowers are rendered conspicuous not only by the usually large, bright yellow corolla, but also by the similarly coloured branched stamens (described as 'bundles'), and the three styles. They are homogamous pollen flowers. The glands on the calyx in many species keep away creeping insects. The flower mechanisms of the various species agree as regards size, number of stamens and possibility of automatic self-pollination, with those of—

508. H. perforatum L. (Herm. Müller, 'Fertilisation,' pp. 139–40; Kirchner, 'Weit. Beob.,' II, pp. 211–12; Kirchner, 'Flora v. Stuttgart,' p. 325; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 49, 152, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 232, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen.')—In the flowers of this species the three spreading styles are situated between the three bundles of filaments. The anthers dehisce upwards—the innermost first—and do not usually touch the stigmas, which are on the same level, so that cross- and self-pollination alike depend upon insect-visits. When anthesis is over, the petals and stamens are drawn inwards, the stigmas being thus generally brought into contact with the anthers, which are still covered with pollen, so that automatic self-pollination takes place if insect-visits have failed.

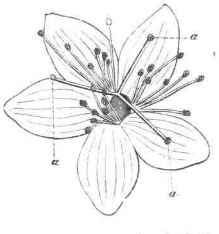

FIG. 61. *Hypericum perforatum, L.* (after Herm. Müller). Flower seen obliquely from above. *a, a, a,* the three stigmas.

VISITORS.—Hermann Müller (H. M.) in Westphalia, Buddeberg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein and Pomerania, have observed the following.—

A. Coleoptera. *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, po-dvg. (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 2. Anthrax flava *Mg.*, po-dvg. (?) (H. M., Thuringia); 3. A. maura *L.* (H. M., Thuringia); 4. Argyromoeba sinuata *Fall.*, vainly searching for nectar (H. M.); 5. Bombylius canescens *Mikan.*, skg. (H. M.). (*b*) *Empidae*: 6. Empis livida *L.*, do. (H. M.). (*c*) *Muscidae*: 7. Musca sp. (H. M.). (*d*) *Syrphidae*: 8. Ascia podagrica *F.*, po-dvg. (H. M.); 9. Eristalis aeneus *Scop.* ♀, po-dvg. (Kn.,

Rügen); 10. E. arbustorum *L.*, do. (H. M.); 11. E. nemorum *L.* (H. M., Kn.); 12. E. sepulcralis *L.*, do. (H. M.); 13. E. sp. (Kn.); 14. E. tenax *L.*, do. (H. M.); 15. Helophilus pendulinus *L.*, do. (H. M.); 16. H. trivittatus *F.*, do. (H. M.); 17. Melanostoma mellina *L.*, do. (H. M.); 18. Melithreptus pictus *Mg.*, do. (H. M.); 19. M. scriptus *L.*, do. (H. M.); 20. Syrphus balteatus *Deg.*, do (H. M.); 21. S. ribesii *L.*, do. (H. M., Kn.); 22. S. sp., do. (Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 23. Andrena shawella *K.* ♀, po-cltg. (H. M.); 24. A. dorsata *K.* ♀, do. (H. M.); 25. A. fulvicrus *K.* ♀, do. (Budd.); 26. A. nigriceps *K.* ♀, do. (Kn.); 27. Apis mellifica *L.* ☿, do. (Kn.); 28. Bombus agrorum *F.* ♀, do. (H. M., Kn.); 29. B. lapidarius *L.*, do. (H. M.); 30. B. rajellus *K.* ♀, do. (H. M.); 31. B. terrester *L.* ☿, do. (H. M., Kn.); 32. Cilissa melanura *Nyl.* ♀, do. (H. M.); 33. Halictus cylindricus *F.* ♀, do. (Budd.); 34. H. malachurus *K.* ♀, do. (Budd.); 35. H. morio *F.* ♀, do. (Budd.); 36. Nomada lateralis *Pz.* ♀, skg. (H. M.); 37. N. lineola *Pz.* ♀, do. (H. M.); 38. Prosopis armillata *Nyl.*, po-cltg. (H. M.); 39. Saropoda bimaculata *Pz.*, skg. (H. M.). (*b*) *Tenthredinidae*: 40. Tenthredo sp., vainly searching for nectar (H. M.). **D. Lepidoptera.** *Rhopalocera*: 41. Hesperia sylvanus *Esp.*, trying to bore into the tissues (H. M.); 42. Melitaea athalia *Rott.*, do. (H. M.); 43. Pieris rapae *L.*, do. (H. M.); 44. Epinephele janira *L.*, do. (H. M.).

The following were noticed by Loew in Silesia ('Beiträge,' pp. 28, 46).—

A. Coleoptera. *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, po-dvg; 2. Chrysomela varians *Schall.* **B. Diptera.** *Syrphidae*: 3. Didea intermedia *Lw.*, po-dvg.; 4. Eristalis horticola *Deg.*, do. **C. Hymenoptera.** *Apidae*: 5. Bombus terrester *L.*, po-cltg.; 6. Diphysis serratulae *Pz.* ♀, do. **D. Lepidoptera.** *Rhopalocera*: 7. Argynnis paphea *L.*, vainly seeking for nectar.

In Bremen Alfken saw 3 po-cltg. humble-bees,—1. Bombus lapidarius *L.* ☿; 2. B. terrester *L.* ☿; 3. B. hortorum *L.* ☿. MacLeod noticed a humble-bee, 3 hover-flies and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 225–6), and Bombus terrester *L.*, po-cltg., in the Pyrenees (op. cit., iii, 1891, p. 400).

Willis observed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *F.*, freq., po-dvg. **B. Diptera.** (*a*) *Empidae*: 2. Tachydromia sp., po-dvg.; 3. Anthomyia radicum *L.*, very freq., po-dvg.; 4. A. sp., po-dvg. (*b*) *Muscidae*: 5. Calliphora erythrocephala *Mg.*, do.; 6. C. vomitoria *L.*, do.; 7. Morellia sp., do.; 8. Mydaea sp., freq., po-dvg.; 9. Stomoxys calcitrans *L.*, do. (*c*) *Syrphidae*: 10. Eristalis pertinax *Scop.*, freq., po-dvg.; 11. Platycheirus albimanus *F.*, po-dvg.; 12. P. peltatus *Mg.*, freq., po-dvg.; 13. Syritta pipiens *L.*, do.; 14. Syrphus balteatus *Deg.*, do.; 15. S. topiarius *Mg.*, po-dvg. **C. Hemiptera.** 16. An undetermined sp. **D. Hymenoptera.** (*a*) *Apidae*: 17. Bombus agrorum *F.*, vainly searching for nectar. (*b*) *Ichneumonidae*: 18. An undetermined sp.

In Dumfriesshire, Apis, 4 humble-bees, an Empid, 8 hover-flies, and 4 Muscids have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 32).

509. H. hirsutum L. (Herm. Müller, 'Fertilisation,' pp. 140–1; Kirchner, 'Flora v. Stuttgart,' p. 327.)—This species has somewhat smaller flowers and fewer anthers than the last. As Hermann Müller explains, the three groups of anthers are therefore separated by wider spaces, so that automatic self-pollination is prevented in the open flower. It regularly takes place, however, by the closing of the flower even before the end of anthesis. The result, according to Hermann Müller, seems to be complete fertility.

Visitors.—In Dumfriesshire, 2 humble-bees, an Empid, 3 Muscids, and a hover-fly have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 34).

510. H. quadrangulum L. (Herm. Müller, 'Fertilisation,' p. 141, 'Weit. Beob.,' II, p. 212; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 266; Kirchner, 'Flora v. Stuttgart,' p. 325; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen.')—Hermann Müller says that this species is intermediate between the two foregoing ones in respect of the size of the flowers and the number of stamens. He observed that in open flowers the stigmas were not in immediate contact with the anthers. Probably, however, when fading takes place, there is a contraction of parts followed by automatic self-pollination.

VISITORS. — Herm. Müller (H. M.) and myself (Kn.) have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Aricia vagans *Fall.*, po-dvg. (H. M.). (*b*) *Syrphidae*: 2. Syritta pipiens *L.*, po-dvg. (Kn.); 3. Syrphus balteatus *Deg.*, do. (H. M.); 4. S. ribesii *L.*, do. (Kn.). **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, po-cltg. (Kn.); 6. Bombus agrorum *F.* ☿, do. (Kn., Rügen); 7. B. terrester *L.* ☿, do. (Kn.). The latter humble-bee was also observed by Loew in the Berlin Botanic Garden, po-cltg.

In Dumfriesshire, Apis, 3 humble-bees, a Dolichopid, and 3 Muscids have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 32).

511. H. commutatum Nolte (= H. perforatum × H. quadrangulum).

VISITORS.—Loew observed Apis mellifica *L.* ☿ and Bombus terrester *L.* ☿, both po-cltg., in the Berlin Botanic Garden.

512. H. tetrapterum Fries. (Herm. Müller, 'Weit. Beob.,' II, p. 212; Kirchner, 'Flora v. Stuttgart,' p. 325.)—In this species again the flower mechanism is similar to those of allied forms. Kirchner states that automatic self-pollination is usually impossible in the open flower.

VISITORS.—Herm. Müller gives the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *F.*, po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Aricia incana *Wiedem.*, freq., po-dvg.; 3. A. vagans *Fall.*, do. (*b*) *Syrphidae*: 4. Syrphus balteatus *Deg.*, po-dvg. **C. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, po-cltg.; 6. Bombus terrester *L.* ♀ and ☿, do.

MacLeod observed a humble-bee and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 226).

513. H. pulchrum L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 49.)—The flower mechanism once more agrees with those of related species. The diameter of the flowers of plants studied by me in the North Frisian Islands is about 1·5 cm.; the number of stamens is about fifty.

VISITORS.—MacLeod observed small Diptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 378).

In Dumfriesshire, Apis and numerous Diptera were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 53).

514. H. humifusum L. (Herm. Müller, 'Fertilisation,' p. 141; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 226; Kirchner, 'Flora v. Stuttgart,' p. 326; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 52.)—The flowers of this species observed by me in the North Frisian Islands had only 10–15 stamens. Automatic self-pollination regularly takes place in closing flowers, and often also even in open ones (Herm. Müller). Kerner says that the flowers do not open in unfavourable

weather, and then automatic self-pollination takes place as a result of the pseudo-cleistogamy.

According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii. 1896), the diameter of the flower may be as much as 8 mm.; the petals have black marginal glands. The pollen is yellow, ovoid, delicately tuberculated, about 31 μ long and 15 μ broad.

VISITORS.—In Dumfriesshire, several Muscidae have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 33).

515. H. Elodes Huds. (=Elodes palustris *Spach*). (MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 226–7.)—The base of each yellow petal bears a split scale, which perhaps secretes nectar. Above these scales, between the staminal bundles, there are small liguliform bifid glands (? modified stamens) which are applied to the ovary, and perhaps also secrete nectar.

VISITORS.—In Dumfriesshire, a Muscid has been observed (Scott-Elliot, 'Flora of Dumfriesshire,' p. 34).

XX. ORDER *MALVACEAE* R. BR.

LITERATURE.—Knuth, 'Grundriss d. Blütenbiol.,' p. 32.

The bright colour of the large corolla, and often also of the pyramid of stamens, renders the flower conspicuous. Nectar is secreted between the bases of the petals, or at the bottom of the calyx. Many species, therefore, belong to the flower class **C.** Individual genera (Hibiscus) include nectarless species, which consequently belong to class **Po.** Almost all the Malvaceae are markedly protandrous. The South Brazilian species of Abutilon are pollinated by humming-birds, which discharge their function so actively that the possibility of autogamy has been lost (Herm. Müller, 'Fertilisation,' p. 146).

147. Malva L.

Flowers protandrous, with concealed nectar, secreted as above described.

516. M. sylvestris. (Sprengel, 'Entd. Geh.,' pp. 347–50; Herm. Müller, 'Fertilisation,' pp. 142–4, 'Weit. Beob.,' II, p. 221; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 47–8, 152; Kirchner, 'Flora v. Stuttgart,' p. 331.)—The red petals are marked with dark circles, which serve as nectar-guides, and above the secretion are ciliary hairs serving as a protection. In the first stage of anthesis the anthers meet in the form of a pyramid above the filaments—which are united below—completely covering the still immature stigmatic branches enclosed in the staminal tube, so that the mature anthers alone occupy the middle of the flower. After they have dehisced the stamens curve downwards, while the stigmatic branches develop, and spread out so that the papillae on their inner surfaces now occupy the place where the anthers were at first situated. Insects visiting the flower must, therefore, regularly effect crossing. Automatic self-pollination is excluded, and is unnecessary, owing to the large number of insect visitors.

VISITORS.—Herm. Müller (H. M.) and myself (Kn.) in Central and North Germany have observed the following).—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Mantura fuscicornis *L.*, po-dvg. (H. M.). (*b*) *Nitidulidae*: 2. Meligethes, po-dvg. (H. M.). (*c*) *Telephoridae*: 3. Danacea pallipes *Pz.*, resting in the flowers (H. M.). **B. Diptera.** (*a*) *Muscidae*: 4. Ulidia erythrophthalma *Mg.*, resting in the flowers (H. M.). (*b*) *Stratiomyidae*: 5. Sargus cuprarius *L.*, a useless guest (H. M.). (*c*) *Syrphidae*: 6. Rhingia rostrata *L.*, freq., skg. (H. M.). **C. Hemiptera.** 7. Pyrrhocoris apterus *L.*, skg. **D. Hymenoptera.** (*a*) *Apidae*: 8. Andrena fulvicrus *K.* ♂, skg. (H. M.); 9. A. gwynana *K.* ♀, do. (H. M.); 10. A. parvula *K.* ♂, do. (H. M.); 11. Apis mellifica *L.* ☿, freq., skg. (H. M., Kn.); 12. Bombus agrorum *F.* ☿, skg. (H. M.); 13. B. hortorum *L.* ♀, do. (H. M.); 14. B. lapidarius *L.* ♀, freq., skg. (H. M., Kn.); 15. B. agrorum *F.* ♀ and ☿, skg. (H. M.); 16. B. pratorum *L.* ♂, ♀ and ☿, in large numbers, skg. (H. M.); 17. B. sylvarum *L.* ♀, skg. (H. M.); 18. Chelostoma campanularum *L.* ♂, do. (H. M.); 19. C. nigricorne *Nyl.* ♂ and ♀, very freq., skg. and po-dvg. (H. M.); 20. Cilissa haemorrhoidalis *F.* ♂ and ♀, skg. (H. M.); 21. Coelioxys conoidea *Ill.* ♂, do. (H. M.); 22. C. elongata *Lep.* ♂ and ♀, do. (H. M.); 23. Halictus albipes *F.* ♀, freq., skg. (H. M.); 24. H. cylindricus *F.* ♀, skg. (H. M.); 25. H. flavipes *F.* ♀, do. (H. M.); 26. H. maculatus *Sm.* ♀, do. (H. M.); 27. H. morio *F.* ♂ and ♀, do. (H. M.); 28. H. nigerrimus *Schenck* ♀, do. (H. M.); 29. H. smeathmanellus *K.* ♀, do. (H. M.); 30. H. zonulus *Sm.* ♂, do. (H. M.); 31. Megachile ligniseca *K.* ♂, do. (H. M.); 32. M. willughbiella *K.* ♂, do. (H. M.); 33. Nomada lateralis *Pz.* ♀, do. (H. M.); 34. Osmia aenea *L.* ♂, do. (H. M.); 35. O. aurulenta *Pz.* ♀, do. (H. M.); 36. P. communis *Nyl.* ♂ and ♀, seen repeatedly, skg. (H. M.); 37. P. dilatata *K.* ♂, skg. (H. M.); 38. P. hyalinata *Sm.* ♂, do. (H. M.); 39. P. pictipes *Nyl.* ♂, do. (H. M.); 40. P. signata *Pz.* ♂, do. (H. M.); 41. Stelis aterrima *Pz.* ♂, do. (H. M.); 42. S. minuta *Lep.* ♂, do. (H. M.). (*b*) *Ichneumonidae*: 43. Ichneumon sp., vainly searching for nectar (?) (H. M.). (*c*) *Vespidae*: 44. Odynerus melanocephalus *L.* ♀, do. (H. M.). **E. Lepidoptera.** *Rhopalocera*: 45. Pieris rapae *L.*, skg. (H. M.).

Schenck noticed Osmia caerulescens *L.* in Nassau, and Alfken saw the following Apidae in Bremen.—

1. Bombus agrorum *F.* ☿, freq., skg. and po-cltg.; 2. B. arenicola *Ths.* ☿, do.; 3. B. derhamellus *K.* ☿, skg. and po-cltg., ♂, skg.; 4. B. proteus *Gerst.* ♀; 5. B. sylvarum *L.* ☿; 6. Coelioxys elongata *Lep.* ♀, skg.; 7. C. rufescens *Lep.* ♂ and ♀, do.; 8. Eriades florisomnis *L.* ♀, very freq., skg. and po-cltg.; 9. E. nigricornis *Nyl.* ♀, do.; 10. E. truncorum *L.* ♀; 11. Megachile centuncularis *L.* ♂; 12. M. willughbiella *K.* ♀; 13. Osmia caerulescens *L.* ♀; 14. Podalirius furcatus *Pz.* ♂; 15. Prosopis communis *Nyl.* ♂ and ♀.

Schletterer observed the following bees at Pola.—

1. Andrena albopunctata *Rossi*; 2. Colletes fodiens *Ltr.*; 3. Halictus scabiosae *Rossi*; 4. Megachile muraria *L.*; 5. Osmia andrenoides *Spin.*; 6. O. rufohirta *Ltr.*

Loew saw two bees—Apis mellifica *L.* ☿, po-cltg., and B. terrester *L.* ♀, do.—and a butterfly—Pieris brassicae *L.*, skg.—in the Berlin Botanic Garden. MacLeod noticed Apis and a small fly in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 227–8).

In Dumfriesshire, 2 humble-bees and 2 hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 36).

Smith observed the following *Apidae* in England. — 1. Andrena gwynana *K.*, 2nd generation; 2. Stelis aterrima *Pz.*; 3. S. phaeoptera *K.*

The very numerous bees observed by Herm. Müller—with the exception of one species (Chelostoma nigricorne *Nyl.*)—never collected pollen, but were always nectar-suckers, though they constantly covered themselves with the spinulose pollen-grains. The above-named species of bee, however, collected unusually large pollen-balls.

Herm. Müller calls attention ('Fertilisation,' p. 14) to a peculiarity of the flowers of this species, i. e. that they are not adequately protected against nectar-thieves. In the afternoon, when the flowers begin to close, the honey-bee frequently thrusts its proboscis between the five sepals of blossoms which are still fresh though shut, and thus empties the nectar receptacle from outside. On some few occasions Müller even observed bees which had rifled several such flowers in this way, continuing their depredations on neighbouring ones that were still open.

517. **M. rotundifolia** L. (= M. borealis *Wallm.*). (Herm. Müller, 'Fertilisation,' pp. 142–4, 'Weit. Beob.,' II, p. 221; Warnstorf, Verh. bot. Ver., Berlin, xxxvii, 1895.)—The flower mechanism of this species at the beginning of anthesis is the same as that of the last one. But, in correlation with its much smaller and less brightly coloured flowers, M. rotundifolia is capable of automatic self-pollination, which is necessary for the maintenance of the species since the number of visitors is naturally much smaller. The stamens remain so far erect that the pollen-covered anthers are touched by the recurved stigmatic branches (see Fig. 60).

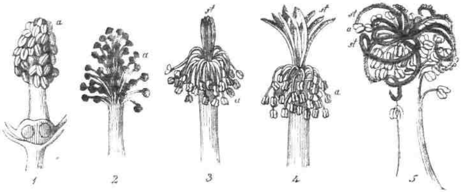

FIG. 62. *Malva sylvestris*, *L.*, and *M. rotundifolia*, *L.* (after Herm. Müller). *M. sylvestris*: (1) Column of stamens in the bud, enclosing the styles. (2) Sexual organs in the first (male) stage. (3) The same in the transition from the first to the second stage. (4) The same in the second (female) stage. (5) *M. rotundifolia* in the last stage, showing self-pollination. *a*, anthers; *st*, stigmas.

Warnstorf gives a somewhat different account, as follows.—Most of the German species of Malva, such as M. Alcea, M. sylvestris, and M. neglecta, possess strongly protandrous flowers, so that self-pollination appears to be excluded, at least in the first stage, though later on it is possible, since some of the large thickly spinulose pollen-grains remain adhering to the dehisced anthers. But M. rotundifolia, on the other hand, has very small inconspicuous flowers, usually concealed under a dense covering of the leaves. They can scarcely depend upon insect-visits, and are almost homogamous. (See, however, the appended list of visitors.) Even at the beginning of anthesis, the stigmas have more or less curved outward to receive pollen, and are at once seen on looking down into the open flower. Owing to the smallness of the hidden flowers, insect-visits are rendered impossible, or at least very unlikely, but homogamy completely compensates for this. In Buslar (Pomerania), where this species—as well as M. neglecta—is quite common, Warnstorf only on a few occasions observed in the flowers a few winged ants, upon the wings of which were numerous pollen-grains, so that they were clearly able to effect cross-pollination.

The diameter of the pollen-grains in M. rotundifolia is about 100 μ, in M. neglecta about 112 μ, and in M. sylvestris as much as 144 μ. In all these species they are closely beset with long spines (Warnstorf).

Visitors.—Herm. Müller observed the following.—

A. Hymenoptera. *Apidae*: 1. Anthophora quadrimaculata *F.* ♂; 2. Apis mellifica *L.* ☿; 3. Bombus agrorum *F.* ☿; 4. Halictus morio *F.* ♂; 5. H. tetrazonius *Kl.* ♀; all skg. **B. Hemiptera.** 5. Pyrrhocoris aptera *L.*, skg.

MacLeod saw Apis, 2 sp. of Halictus, Syritta, and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 229), and an Apid in the Pyrenees.

518. M. neglecta With. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 48, 152.)—The flower mechanism of this species is intermediate between those of M. sylvestris and M. rotundifolia. Here again, at the beginning of anthesis, the pyramid of anthers borne on the united filaments completely encloses the still completely immature stigmatic branches. After dehiscence the upper free ends of the filaments bend downwards, so as to uncover the previously enclosed stigmas. These now spread out in all directions, curving backwards so far that the papillae on their inner sides

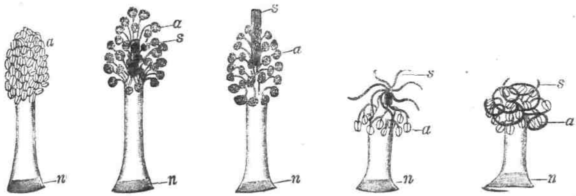

FIG. 63. *Malva neglecta, With.* (Magnified about 5 times, after removal of calyx and corolla. From nature.) (1) Bud condition: column of stamens with unripe anthers. (2) Early male condition: column of stamens with dehiscing anthers surrounding the immature stigmas. (3) Later male condition: the styles project somewhat from the column of stamens, otherwise as before. (4) Early hermaphrodite condition (adapted to cross-pollination): the receptive stigmas project above the stamens (which are directed downwards, but still covered with pollen) and spread out like a star in the entrance to the flower. (5) Later hermaphrodite condition (adapted to automatic self-pollination): the stigmas have rolled themselves spirally round the anthers, which are still covered with pollen. *a*, stamens; *s*, stigmas; *n*, annular nectary ring.

project freely, and occupy the place where the anthers were at first situated. Insects coming from a flower in the first stage to one in the second stage must consequently effect cross-pollination. Towards the end of anthesis, the stigmatic branches curve downwards so far as to come into contact with the stamens which are still covered with pollen to some extent; and thus automatic self-pollination takes place, if insect-visits have failed.

Visitors.—In the island of Föhr I only observed the honey-bee, skg. and po-cltg.

519. M. mauritiana L.—Kirchner ('Flora v. Stuttgart,' p. 332) states that the flower mechanism of this species agrees with that of M. sylvestris.

520. M. Alcea L. (Herm. Müller, 'Fertilisation,' p. 144, 'Weit. Beob.,' II, p. 221; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—As No. 519.

VISITORS.—Herm. Müller (H. M.) in Westphalia, and Buddeberg (Budd.) in Nassau, observed the following *Apidae*.—

1. Andrena schrankella *Nyl.* ♂, skg. (H. M.); 2. Apis mellifica *L.* ☿, very freq., skg. (H. M.); 3. Chelostoma nigricorne *Nyl.* ♂, skg. (H. M.); 4. Cilissa haemorrhoidalis *F.* ♂, do. (H. M., Budd.); 5. Halictus cylindricus *F.* ♀, do. (H. M.); 6. Rhophites canus *Ev.* ♂, do. (Budd.).

Friese saw Eucera malvae *Rossi* at Bozen.

Loew noticed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus balteatus *Deg.*, po-dvg. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, po-cltg. **C. Lepidoptera.** *Rhopalocera*: 3. Pieris brassicae *L.*, skg.; 4. Spilothyrus alceae *Esp.*, do.

521. **M. moschata** L. (Herm. Müller, 'Fertilisation,' p. 144.)—As No. 519.

VISITORS.—Herm. Müller observed the following.—

A. Diptera. *Bombyliidae*: 1. Systoechus sulphureus *Mikan.*, skg. **B. Hymenoptera.** *Apidae*: 2. Andrena coitana *K.* ♂, skg.; 3. Apis mellifica *L.* ☿, do.; 4. Chelostoma nigricorne *L.* ♀, do. **C. Lepidoptera.** *Rhopalocera*: 5. Hesperia sylvanus *Esp.*, skg.

MacLeod saw Bombus lapidarius *L.* ☿ in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 401).

In Dumfriesshire, Apis and 2 humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 35).

148. **Lavatera** L.

Like the last genus.

522. **L. thuringiaca** L.—The large pale rose-red flowers of this species are protandrous, according to Schulz ('Beiträge,' I, p. 26). The anthers of the 70–90 stamens often remain closed for a time after the flower opens. Dehiscence begins above, and after it is over the filaments do not curve downwards. Before the lower anthers have shed their pollen, the styles—which have so far been enclosed in the tube formed by the filaments—elongate, and curve outwards until the stigmatic branches touch the anthers. But the latter are usually destitute of pollen at this stage, so that automatic self-pollination is unusual.

VISITORS.—Loew observed the honey-bee, po-cltg., in the Berlin Botanic Garden.

523. **L. trimestris** L.—

VISITORS.—Schenck observed the fossorial wasp Crabro serripes *Pz.* in Nassau.

149. **Kitaibelia** Willd.

524. **K. vitifolia** Willd.—

VISITORS.—Loew observed the hover-fly Syrphus balteatus *Deg.*, po-dvg., in the Berlin Botanic Garden.

150. **Althaea** L.

Like Malva.

525. **A. ficifolia** Cav.—This species is self-sterile (Comes, 'Ult. stud. e consideraz. sulla impollinaz. delle piante').

Visitors.—Loew observed two bees in the Berlin Botanic Garden—Bombus terrester *L.* ♂, skg. and dusting itself thickly with pollen, and Psithyrus vestalis *Fourcr.* ♂, do.

526. A. rosea Cav. (Kirchner, 'Flora v. Stuttgart,' p. 333; Knuth, 'Bloemenbiol. Bijdragen.')—The very large white, yellow, red or blackish flowers of this well-known ornamental plant are markedly protandrous. Their diameter is 6–7 cm.; each petal is about 4 cm. long, and 5–6 cm. broad above. Nectar is secreted by five yellow areas at the bottom of the calyx, between the bases of the petals. It is protected from rain and small insects by hairs on the petals. Automatic self-pollination takes place if insect-visits fail, the stigmas curving back among the anthers that have not yet lost all their pollen.

Visitors.—I observed Apis mellifica *L.* and Bombus terrester *L.* Both sucked persistently, although I was unable to taste the nectar. They flew from flower to flower, skg. in each, and constantly effecting cross-pollination. Loew noticed the same visitors in the Berlin Botanic Garden.

Alfken observed the humble-bees Bombus hortorum *L.* ♂, and B. agrorum *F.* ♂, skg., at Bremen. Rössler at Wiesbaden saw the Geometrid Ortholitha cervinata *S.V.*

For the Tyrol, Schletterer describes Bombus pascuorum *Scop.*, which is widely distributed in South Europe.

527. A. officinalis L. (Knuth, 'Bloemenbiol. Bijdragen.')—The flowers are the same in structure as those of the last species, but considerably smaller, their diameter being 2–3 cm., while the petals are 2 cm. long, and about as broad.

Visitors.—In the Kiel Botanic Garden I observed the honey-bee and Bombus terrester, skg. Schletterer describes the garden humble-bee for the Tyrol.

528. A. cannabina L.—

Visitors.—In the Botanic Garden at Berlin Loew observed the following.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*, po-dvg.; 2. E. tenax *L.*, do. **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, po-cltg.

151. Hibiscus L.

Protandrous pollen flowers.

529. H. Trionum L.—The flowers of this species are yellow with a purple base. Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 212) says that they open between 8 a.m. and noon. The pollen-covered anthers rise up in the middle of the newly opened flower, and the free parts of the filaments soon curve downwards so that the stigmatic branches, as they become receptive, may occupy the place of the anthers. Insect visitors must therefore effect cross-pollination. After a few hours the styles become S-shaped, and curve downwards to such an extent that the stigmatic papillae come into contact with the anthers, which are still covered with pollen.

152. Abutilon Tourn.

530. A. Avicennae DC. (= Sida Abutilon *L.*). — Kerner states that the flowers of this species open from 10 to 6 o'clock, and present the same arrangements as those of Hibiscus Trionum.

153. Anoda Cav.

Protandrous pollen flowers.

531. **A. hastata** Cav. (Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.,' pp. 48–9.)—As in the case of Malva, the anthers at first form a pyramid, which encloses the still undeveloped styles. The upper stamens are erect, the lower ones are curved back. The anthers of the upper stamens dehisce first; those of the lower ones follow them, and at the same time their filaments become upright. We can now see the styles, which are curved downwards, arranged in five bundles, and closely apposed to the column of filaments. This is beset with hairs, which project between the bundles of styles, protecting the reddish stigmas from contact with insect visitors. When the dehisced stamens curve backwards, the styles erect themselves, so that the stigmas take up the position occupied by the pollen-covered anthers during the first stage of anthesis.

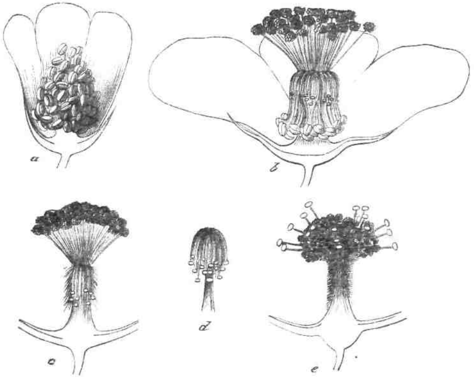

Fig. 64. *Anoda hastata, Cav.* (after Hildebrand). *a.* Condition in the bud. *b.* Beginning of the first (male) stage: some of the stamens are erect and covered with pollen. *c* and *d.* Male stage: all the stamens are erect and their anthers are covered with pollen, while the styles (*d*) are still curved downwards. *e.* Second (female) stage; the styles have become erect.

154. Goethea Nees.

532. **G. coccinea.** (Delpino, 'Altri appar. dicog. recent. osserv.,' p. 59; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.,' p. 19.)—In this species the nectar is secreted by five glands at the bottom of the calyx. The corolla forms a nectar-cover, and the four petals make the protogynous flower conspicuous.

Visitors.—Delpino supposes that these are bees or humming-birds.

155. Pavonia Cav.

533. **P. hastata** Cav.—Heckel (C.-R. Acad. sci., Paris, lxxxix, 1879) states that this species possesses cleistogamous flowers.

156. **Malope** L.

534. **M. grandiflora** F. G. Dietr. (Knuth, 'Blütenbiol. Notizen.')—This species exhibits the same marked protandry as Malva.

VISITORS.—On October 10, 1897, I observed Apis mellifica *L.*, skg., in the Garden of the Kiel Ober-Realschule. This insect dusted the under-side of its body with pollen in flowers that were in the first stage, and transferred some of it to the stigmas of flowers in the second stage.

Schenck observed the fossorial wasp Crabro serripes *Pz.* in Nassau.

XXI. ORDER *STERCULIACEAE* VENT.

157. **Pterospermum** Schreb.

535. **P. acerifolium** Willd.—Lanza ('Note di biol. fior.,' 1894) states that this species is protandrous in the Palermo Botanic Garden. The adynamandrous blossoms are moth flowers.

158. **Cheirostemon** Humb. et Bonpl.

536. **C. platanoides** Humb. et Bonpl.—Lanza (op. cit.) states that autogamy cannot take place. The plants in the Palermo Botanic Garden never set fruits, apparently because the appropriate pollinating agent does not occur there.

159. **Rulingia** R. Br.

537. **R. pannosa** R. Br.—This species is protandrous (Urban, Ber. D. bot. Ges., Berlin, i, 1883, pp. 53–6).

538. **R. corylifolia** R. Grah.—This species is homogamous (op. cit.).

539. **R. parviflora** Endl.—The petals are yellowish-white at first, but become rose-coloured after the pollen has been shed, as in Weigelia (op. cit.).

XXII. ORDER *TILIACEAE* JUSS.

This family is represented in Europe by the genus.

160. **Tilia** L.

Flowers usually whitish, and belonging to class **E.**

540. **T. platyphyllos** Scop. (=T. grandifolia *Ehrh.*) and **541. T. ulmifolia** Scop. (=T. parvifolia *Ehrh.*). (Sprengel, 'Entd. Geh.,' pp. 275–6; Herm. Müller, 'Fertilisation,' pp. 146–7, 'Weit. Beob.,' II, p. 219; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 227; Hildebrand, Bot. Ztg., Leipzig, xxvii, 1869; Kirchner, 'Flora v. Stuttgart,' p. 329; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 48, 152 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' 'Bloemenbiol. Bijdragen.')—The flower mechanism and visitors are the same in these two species, but the latter blossoms about a fortnight later than the former. As the flowers are pendent, the

nectar, secreted and sheltered by the hollowed sepals, is protected from rain. The yellowish flowers smell strongly of honey, and are protandrous, as Hildebrand first pointed out (op. cit.). The numerous stamens curve outwards, projecting beyond sepals and petals. Insects settling upon the hanging blossoms can therefore only find footing on the stamens and stigmas, or in the space between them. In the younger flowers, therefore, they dust themselves with pollen, and transfer this to the stigmas of the older flowers. Automatic self-pollination is scarcely possible, for the stamens remain curved outwards to the end of anthesis. The flowers, however, are visited by so many insects that crossing is certain. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) says that the pollen-grains of T. platyphyllos are white, tetrahedral, closely tuberculated, opaque, with three germinating processes in the middle of the edges, and averaging 31 μ in diameter. Jordan states that the exposed nectar collects in two little pits on the bases of the sepals, and is accessible even to very short-tongued insects. Besides the honey-bee which visits the flowers in thousands, and collects nectar only, not pollen, other Apidae, as well as Syrphidae and Muscidae, are very frequent visitors.

VISITORS.—Herm. Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Lucilia cornicina *F.*, skg. (H. M.); 2. Musca domestica *L.*, do. (H. M., Kn.); 3. Sarcophaga carnaria *L.*, do. (H. M., Kn.). (*b*) *Syrphidae*: 4. Eristalis arbustorum *L.*, skg. (H. M.); 5. E. nemorum *L.*, do. (H. M., Kn.); 6. E. sepulcralis *L.*, do. (H. M.); 7. E. tenax *L.*, do. (H. M., Kn.); 8. Helophilus floreus *L.*, very freq., skg. and po-dvg. (H. M.); 9. Volucella bombylans *L.*, skg. (Kn.); 10. V. pellucens *L.*, do. (H. M.). (*c*) *Tabanidae*: 11. Tabanus bovinus *L.*, do. (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 12. Apis mellifica *L.* ☿, skg. (H. M., Kn.); 13. Bombus agrorum *F.* ♀, freq., skg. (H. M.); 14. B. lapidarius *L.*, skg. (Kn.); 15. B. soroënsis *F.*, var. proteus *Gerst.*, do. (Kn.); 16. B. terrester *L.*, do. (Kn.); 17. Prosopis, freq. (H. M.). (*b*) *Sphegidae*: 18. Oxybelus uniglumis *L.*, freq., nect-lkg. (H. M.).

Alfken saw the following at Bremen.—

A. Diptera. *Empidae*: 1. Empis tessellata *F.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Bombus agrorum *F.* ☿ and ♀; 3. B. muscorum *F.* ☿ and ♀. (*b*) *Vespidae*: 4. Vespa crabro *L.* ☿ and ♀.

542. T. tomentosa Moench. (Kirchner, 'Flora v. Stuttgart,' p. 330.)—This Hungarian species possesses bright yellow homogamous flowers, in which the stigma projects beyond the anthers, so that cross-pollination is assured in the event of insect-visits.

543. T. sylvestris Desf.—

VISITORS.—MacLeod saw a humble-bee and 4 Diptera in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 400).

XXIII. ORDER *LINEAE* DC.

Flowers homogamous, with concealed nectar. Dimorphism frequent.

Alefeld says that many European, Asiatic, and North African species are dimorphous, while the Cape species, and those native to North and South America, are monomorphous.

161. Linum L.

544. L. catharticum L. (Herm. Müller, 'Fertilisation,' p. 147; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 238–9; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The filaments of the small white homogamous flowers are fused at the base into a fleshy ring, which, as Herm. Müller explains, secretes on its outer side five drops of nectar from five small, flat pits situated in the middle of the filaments. The five petals are inserted into the same ring, a little higher than the nectar-pits, and alternating with them. The lower halves of their edges are closely applied, but their bases suddenly narrow, so as to leave a small round aperture—*giving access to the nectar—immediately* above each nectar-pit. The anthers are at the same level as the stigmas, but are at first remote from them,

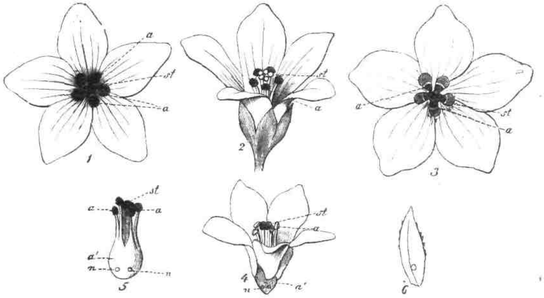

FIG. 65. *Linum catharticum*, *L.* (after Herm. Müller). (1) Young flower, seen from above: the anthers are still remote from the stigmas. (2) The same seen obliquely from above. (3) Somewhat older flower seen from above: the anthers are applied to the stigmas (4) Flower after removal of the calyx to show the insertion of the petals and the position of the nectaries. (5) Stamens and stigmas in the act of automatic self-pollination. (6) Sepal seen from the inner side, with a drop of nectar. *a*, anthers; a^1, the united filaments; *st*, stigma; *n*, nectaries.

so that insect visitors may effect either self- or cross-pollination. Failing such visitors, automatic self-pollination takes place, the stamens bending more and more inwards, and the flowers closing in the evening.

Warnstorf describes the flowers as slightly protogynous, the stigmas maturing before the flower opens. The pollen-grains are large, golden-yellow, spherical or ellipsoidal, tuberculated, with a maximum length of 50 μ and breadth of 30–37 μ.

Visitors.—Herm. Müller saw the following.—2 nect-skg. flies, a Bombylid—Systoechus sulphureus *Mikan* in Westphalia—and an Empid—Empis livida *L.* in Thuringia.

MacLeod observed a Syrphid and a Bombylid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 406).

In Dumfriesshire, an Empid, a Muscid, and a hover-fly were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 35).

545. **L. usitatissimum** L. (Sprengel, 'Entd. Geh.,' p. 175; Hildebrand, 'Die Geschlechtsvert. b. d. Pfl.,' p. 75; Herm. Müller, 'Fertilisation,' p. 148, 'Weit. Beob.,' II, p. 219.)—The bright blue flower, according to Hermann Müller, possesses a mechanism which completely agrees with that of the last species. But being more conspicuous, insect-visits are more numerous, so that crossing takes place more frequently. Hildebrand has proved that when automatic self-pollination occurs it is effective.

Visitors.—Sprengel saw a humble-bee; Herm. Müller observed bees—Apis, Halictus cylindricus *F.* — and Lepidoptera — Plusia gamma *L.*, Pieris rapae *L.*; MacLeod noticed one humble-bee and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 239). Cf. L. grandiflorum.

546. **L. tenuifolium** L.—Kerner says that the slightly odorous rose-red flowers of this species fall off as early as the second day of anthesis. According to Kirchner ('Beiträge,' pp. 29–30), who studied the mechanism of the flowers in Wallis, they agree with those of L. usitatissimum as regards homogamy, and the secretion and concealment of nectar, but from the relative positions of the stigmas and anthers—which mature simultaneously—the regular occurrence of cross-pollination may be inferred. Owing to the conspicuousness of the flowers, which have a diameter of 22 mm., this is sure to take place. The five styles which spring from the ovary diverge, while the five filaments—united together below—stand erect between the styles, and at the same level as the stigmas, which are outside them, and at a distance of 3 mm. Even if towards the end of anthesis the petals and styles come into contact, automatic self-pollination does not as a rule take place, for the stigmas are at a higher level than the anthers in the closed flower.

547. **L. Lewisii** L.—Planchon states that each plant of this species bears three different kinds of flower, possessing medium, long, and short styles, respectively.

548. **L. austriacum** L.—

Visitors.—Friese observed Andrena braunsiana *Friese* in Hungary; v. Dalla Torre saw the bee Osmia leucomelaena *K.* ♂ and ♀ in the Innsbruck Botanic Garden, and Schletterer noticed it in the Tyrol.

549. **L. grandiflorum** Desf.—This species was the starting-point of Darwin's research 'On the Existence of Two Forms and their Reciprocal Sexual Relations in several species of the genus Linum' (1863). He showed that fertility was greatest when the long-styled variety was crossed with pollen from the short-styled one, and vice versa. Darwin's investigations also demonstrated that the short-styled variety was more fertile when self-fertilized than the long-styled one, which was almost self-sterile. When both kinds of pollen were put upon one kind of stigma, as a rule only that germinated which was derived from the opposite sort of flower, while that from the same sort either failed to germinate, or did so only to a slight extent.

Visitors.—Frey-Gessner observed two bees—Nomia diversipes *Ltr.* and Systropha curricornis *Scop.*—in Switzerland. Plateau noticed that small Syrphidae went straight from the red flowers of L. grandiflorum to the blue ones of L. usitatissimum.

550. L. perenne L.—Darwin found (op. cit.) that three-quarters of the legitimately pollinated flowers of both varieties were completely fertile, while illegitimately pollinated flowers of the long- and short-styled varieties were, respectively, completely infertile and almost completely fertile. According to Hildebrand's investigations (1864), the short-styled variety is completely infertile both with its own pollen and with that from other flowers of the same plant, and even with pollen from other short-styled plants, while, on the other hand, it is completely fertile with pollen from long-styled flowers.

162. Radiola Dill.

Minute white flowers, probably with concealed nectar.

551. R. linoides Gmel.—MacLeod (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 379) states that in the flowers of this species the four anthers come into contact with the four stigmas, so that automatic self-pollination is inevitable. Owing to the smallness of the flowers, nectaries could not be recognized.

Visitors.—Herm. Müller observed several minute flies.

XXIV. ORDER *MALPIGHIACEAE* JUSS.

163. Camarea St. Hil. and 164. Janusia A. Juss.

In species of these genera, there are cleistogamous as well as chasmogamous flowers.

165. Aspicarpa Rich.

552. A. urens Rich.—H. von Mohl states (Bot. Ztg., Leipzig, xxi, 1863) that this species bears cleistogamous flowers. The same is true for the species of the genus

166. Gaudichaudia H. B. et K. (Kuhn, Bot. Ztg., Leipzig, xxv, 1867.)

167. Bunchosia Rich.

553. B. Gaudichaudiana A. Juss. (Delpino, Bot. Ztg., Leipzig, xxviii, 1870; Hildebrand, op. cit., xxviii, 1870.)—

Visitors.—These are bees—Tetrapodia, Epicharis—which cover their ventral surfaces with pollen, and transfer it to the stigmas of other flowers.

168. Coriaria Niss.

554. C. myrtifolia L.—According to Hildebrand (Bot. Ztg., Leipzig, xxvii, 1869, pp. 494–5), the flowers of this species are markedly protandrous, being purely male in their first stage.

169. Hiptage Gaertn.

555. H. Madablota Gaertn.—Lanza ('Note di biol. fior.,' 1894) states that the flowers of this species are protogynous in the Palermo Botanic Garden. There is a single nectary between the two upper petals turned towards the floral axis. The flower mechanism resembles that of Aesculus.

Visitors.—The pollen is transferred by bees, as in the horse-chestnut.

170. Cratoxylon Blume.

556. C. formosum Bentham et Hook. f. — Darwin ('Different Forms of Flowers') states that the species possess dimorphous flowers.

XXV. ORDER *GERANIACEAE* DC.

1. Tribe Geranieae.

Literature.—Herm. Müller, 'Fertilisation,' pp. 149–60; Knuth, 'Grundriss d. Blütenbiol.,' p. 37.

The flowers are usually bright in colour, and very frequently red. They differ greatly in size in the various species, and with increasing inconspicuousness, there is proportionate diminution in the number of insect visitors, but increased probability of automatic self-pollination. In most species nectar is secreted by the outer sides of the bases of the five external stamens. Almost all the flowers belong to class **C** as regards concealment of nectar, but certain species may be placed in class **H**, not because the nectar is more deeply situated, but because the flowers hang in such a way that only very expert visitors can reach it. The flowers are mostly protandrous, rarely homogamous or protogynous. The greater the probability of insect-visits the more marked is the dichogamy. Besides hermaphrodite flowers, there are smaller female ones in some species, distributed gynodioeciously, as a rule.

171. Geranium L.

Flowers protandrous, rarely protogynous (G. dissectum and G. pusillum), with concealed nectar secreted by the outside of the bases of the five inner stamens. Some of them are bee flowers. Jordan states that in the erect flowers belonging to class **C**, insect visitors alight on the petals, while in the case of the pendulous flowers—belonging to class **H**—they settle on the stamens and pistil.

557. G. palustre L. (Sprengel, 'Entd. Geh.,' pp. 335–7; Herm. Müller, 'Fertilisation,' p. 149; Schulz, 'Beiträge,' I, p. 28; Kirchner, 'Flora v. Stuttgart,' p. 335; Knuth, 'Bloemenbiol. Bijdragen.')—The markedly protandrous flowers of this species spread out their purple-red petals with paler claws to form a surface 30–40 mm. in diameter, which is turned to the sun. The nectar-guides are dark lines on the corolla, converging to the middle of the flower. Nectar is secreted in abundance by five glands on the outer side of the bases of the five inner stamens. Hairs on the bases of the petals serve to protect the nectar, and prevent the access of rain-drops. The five inner stamens ripen first, and then the five outer ones, and only when these have shed their pollen do the stigmas—that have so far been closely apposed—spread out and project from the middle of the flower. After dehiscing all the stamens bend outwards so far that automatic self-pollination is impossible.

Besides hermaphrodite flowers, Schulz has observed female ones distributed gynodioeciously, or more frequently gynomonoeciously. He also distinguished between large- and small-flowered varieties of the hermaphrodite flowers.

Visitors.—Herm. Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., skg. (H. M.). (*b*) *Syrphidae*: 2. Eristalis tenax *L.*, skg. (H. M.); 3. Helophilus pendulus *L.*, do. (Kn.); 4. Meli-

threptus scriptus *L.*, do. (H. M.); 5. Platycheirus peltatus *Mg.*, do. (H. M.); 6. Rhingia rostrata *L.*, do. (Kn.). **B. Hymenoptera.** *Apidae*: 7. Andrena dorsata *K.* ♂, skg. (H. M.); 8. A. fulvicrus *K.* ♂, do. (H. M.); 9. Apis mellifica *L.* ☿, do. (Kn.); 10. Halictus albipes *F.*, do. (H. M.); 11. H. cylindricus *F.* ♂, do. (H. M.); 12. H. flavipes *F.* ♂, do. (H. M.); 13. H. longulus *Sm.* ♀, do. (H. M.); 14. H. nitidiusculus *K.* ♀ and ♂, do. (H. M.); 15. H. zonulus *Sm.* ♂, do. (H. M.); 16. Prosopis communis *Nyl.* ♀, do. (H. M.). **C. Lepidoptera.** *Rhopalocera*: 17. Pieris rapae *L.*, skg. (Kn.).

Loew saw the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., skg.; 2. Lucilia caesar *L.* (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*, skg.; 4. E. tenax *L.*; 5. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.* ☿, skg.; 7. Chelostoma nigricorne *Nyl.* ♂, do.; 8. Coelioxys rufescens *Lep.* ♀, do.; 9. Halictus cylindricus *F.* ♂, do.; 10. H. nitidiusculus *K.* ♀, do.; 11. H. rubicundus *Chr.* ♀, do.; 12. H. sexnotatus *K.* ♀, do.; 13. H. villosulus *K.* ♂, do.; 14. Prosopis communis *Nyl.* ♂, do.

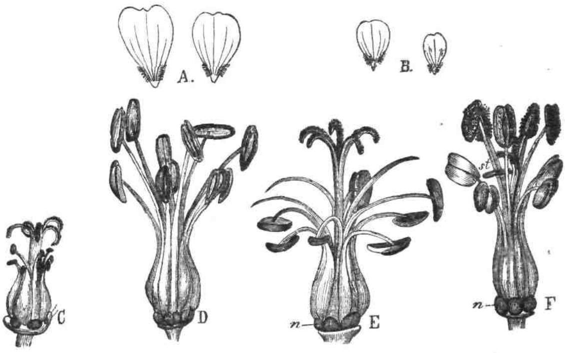

FIG. 66. *Geranium sylvaticum, L.* (after Herm. Müller). *A.* Petals from different plants of the large-flowered variety, natural size. At their bases are the hairs serving as a nectar-cover, which led Sprengel to make his investigations. *B.* Petals from different plants of the small-flowered variety, natural size. *C.* Stamens and pistil of a small female flower. *D.* The same parts of a large flower at the end of the first (male) stage: the anthers have all shed their pollen, the stigmas are still close together. *E.* The same in the second (female) stage. *F.* Sexual organs of a homogamous flower; *n*, nectaries; *st*, stigmas. (*C–F*×7.)

558. G. sylvaticum L. (Sprengel, 'Entd. Geh.,' p. 1; Axell, 'Om Anordning. för Fanerog. Växt. Befrukt.,' p. 36; Herm. Müller, 'Alpenblumen,' pp. 174–8; Schulz, 'Beiträge,' I, pp. 26–7; Loew, 'Blütenbiol. Floristik,' p. 398; Kirchner, 'Flora v. Stuttgart,' pp. 335–6.)—This species served as the starting-point for Christian Konrad Sprengel's classical investigations. The flower mechanism agrees with that of the last species; here again self-pollination is excluded by marked protandry. Besides large flowers with a diameter of about 27 mm., Lindman observed small ones with a diameter of only 15 mm. Schulz states that there are smaller female flowers, in which the stamens are quite short and the anthers vestigial. Among the plants

with hermaphrodite flowers there are rarely some with homogamous flowers, in which automatic self-pollination is possible. In the South Tyrol Schulz observed large-flowered male varieties, in which the branches of the style never spread out. Unisexual flowers are gynodioecious or more rarely gynomonoecious, as well as androdioecious and andromonoecious. In the Scandinavian highlands, Ekstam observed female flowers with vestigial stamens, and small male flowers, in addition to the protandrous hermaphrodite ones.

VISITORS.—Schulz states that many insects visit the flowers in Central Germany.

Herm. Müller saw 8 beetles, 21 Diptera, 24 Neuroptera, and 20 Lepidoptera, in the Alps.

In the Berlin Botanic Garden Loew observed two bees, skg., i. e. Apis mellifica *L.* ☿ and Bombus hortorum *L.* ♀; also Prosopis communis *Nyl.* ♀, skg., in the variety *robustum*. He further noticed two Syrphids—Platycheirus manicatus *Mg.* ♂ and Syrphus annulipes *Zett.*—and a bee (Andrena sp.) in Switzerland.

Schneider (Tromsø Mus. Aarsh., 1894) saw Bombus hypnorum *L.* and B. kirbyellus *Curt.* ♂ and ♀, in Arctic Norway, and Lindman observed Diptera and humble-bees on the Dovrefjeld.

In Dumfriesshire, Apis, freq., 2 humble-bees, 2 short-tongued bees, 3 Empidae, 5 Muscidae, and 2 hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 34).

Glandular hairs on the stem keep off creeping insects from below.

559. **G. pratense** L. (Hildebrand, 'D. Geschlechts-Vert. b. d. Pfl.,' p. 27; Herm. Müller, 'Fertilisation,' p. 150, 'Weit. Beob., II, p. 167; Schulz, 'Beiträge,' I, pp. 27–8; Kirchner, 'Flora v. Stuttgart,' p. 336.)—The mechanism of the markedly protandrous flowers of this species agrees essentially with that of G. palustre. The stamens at first lie on the petals, but become erect when the anthers dehisce, pass to the middle of the flower, and after the pollen has been shed return to their former position. Hildebrand has established by experiments that the stigmas are usually still immature at the time when the anthers are covered with pollen, but become mature when the dehisced stamens bend back. They cease to be receptive when the petals fall away.

Schulz says that the flowers vary considerably in size. In addition to hermaphrodite flowers, he also observed female ones, distributed gynodioeciously or gynomonoeciously.

Warnstorf describes the pollen-grains as white, spherical, coarsely tuberculated, and 100 μ in diameter.

This species also is protected against creeping insects by the sticky nature of the stem.

VISITORS.—The only one I have seen is the honey-bee, skg. Hermann Müller observed the following in Westphalia and Thuringia.—

A. Coleoptera. *Curculionidae*: 1. Coeliodes geranii *Payk.*, skg. (?); 2. Miarus campanulae *L.*, do. (?). **B. Diptera.** (*a*) *Stratiomyidae*: 3. Nemotelus pantherinus *L.* (*b*) *Syrphidae*: 4. Melithreptus pictus *Mg.*, po-dvg. **C. Hymenoptera.** *Apidae*: 5. Andrena coitana *K.* ♀ and ♂, skg.; 6. A. gwynana *K.* ♀, do.; 7. Apis mellifica *L.* ☿, very freq., skg.; 8. Chelostoma campanularum *K.* ♀ and ♂, freq., skg.; 9. C. nigricorne *L.* ♀ and ♂, very freq., skg.; 10. Coelioxys conoidea *Ill.* ♂, skg.; 11. C. elongata *Lep.*, do.; 12. C. quadridentata *L.* ♂, do.; 13. C. rufescens *Lep.* ♀ and ♂, do.; 14.

Halictus albipes *F.* ♂, do.; 15. H. cylindricus *F.* ♂, do.; 16. H. leucozonius *K.* ♀, do.; 17. H. lucidulus *Schenck* ♀, po-cltg.; 18. H. maculatus *Sm.* ♂, skg. (Thuringia); 19. Heriades truncorum *L.*, do.; 20. Osmia fulviventris *F.* ♀, do.; 21. O. rufa *L.* ♀, do.; 22. Prosopis hyalinata *Sm.* ♀, do.; 23. Stelis aterrima *Pz.* ♀ and ♂, do.; 24. S. breviuscula *Nyl.* ♀ and ♂, do.; 25. S. minuta *Lep.* ♂, do.; 26. S. phaeoptera *K.* ♀ and ♂, do. **D. Lepidoptera.** *Rhopalocera*: 27. Pieris napi *L.*, skg.

In Dumfriesshire, Apis (stealing nectar), 2 humble-bees, a short-tongued bee, a Muscid, and a hover-fly have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 38).

Loew observed the following bees in the Berlin Botanic Garden.—

1. Apis mellifica *L.* ☿, skg. (also on the variety *florum album*; 2. Chelostoma nigricorne *Nyl.* ♂, do.; 3. Coelioxys elongata *Lep.* ♀, do.; 4. Megachile argentata *F.* ♂, do.; 5. M. ericetorum *Lep.* ♂, skg.

560. G. argenteum L.—According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. I, II, p. 311), the flowers of this species are as markedly protandrous as those of G. pratense and G. sylvaticum, self-pollination being excluded.

561. G. sanguineum L. (Herm. Müller, 'Fertilisation,' p. 152, 'Weit. Beob.,' II, p. 217, 'Alpenblumen,' p. 174; Schulz, 'Beiträge,' II, p. 56; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller describes the purple-red flowers of this species as protandrous, but capable of automatic self-pollination when insect-visits fail. This arrangement is necessary owing to the shady habitat. When the flower opens, the five inner stamens become erect, and the anthers—which dehisce above and externally—project beyond the still immature stigmas. Meanwhile the five outer stamens curve downwards. On the following day, they too become erect and their anthers dehisce. The stigmas begin to spread out one or two days later, and elongate so as to reach the same level as the anthers, so that if the pollen has not already been removed by insects, either cross- or self-pollination may result from their subsequent visits. The latter must take place automatically should insect-visits fail.

Schulz occasionally observed female flowers, distributed gynomonoeciously or more commonly gynodioeciously. On the Dovrefjeld, the ordinary flowers are quite as large as in Central Germany, but smaller ones—hermaphrodite, male, and female—also occur.

Visitors.—Lindman observed flies and humble-bees on the Dovrefjeld. In Schleswig-Holstein I only noticed the honey-bee, skg.

In Westphalia and Thuringia Herm. Müller did not observe a large number of visitors. They were chiefly flies and bees, which are the actual pollinators. These sometimes alight on the middle of the flower, or may use a petal as a platform from which to suck. He gives the following list.—

A. Coleoptera. *Curculionidae*: 1. Coeliodes geranii *Payk.*, skg. (?); 2. Miarus graminis *Schönh.* **B. Diptera.** *Syrphidae*: 3. Merodon aeneus *Mg.*, freq., skg.; 4. Pelecocera tricincta *Mg.*, po-dvg.; 5. Pipiza sp., do.; 6. Rhingia rostrata *L.*, skg. **C. Hymenoptera.** (*a*) *Apidae*: 7. Bombus pratorum *L.* ☿, po-cltg.; 8. Halictus maculatus *Sm.* ♀, nect-lkg.; 9. H. sexnotatus *K.* ♀, do.; 10. Prosopis sp., skg. (*b*) *Sphegidae*: 11. Oxybelus sp., skg. (*c*) *Tenthredinidae*: 12. Megalodontes cephalotes *F.*, very freq., skg. **D. Lepidoptera.** *Sphingidae*: 13. Ino globulariae *Hbn.*, skg.

Von Fricken saw the small beetle Trachys nana *Hbst.*, very infrequent, in Westphalia. Von Dalla Torre and Schletterer record the cuckoo-bee Nomada guttulata *Schenck* ♂ for the Tyrol.

Herm. Müller saw 2 Hymenoptera in the Alps, and MacLeod noticed 2 Hymenoptera, a Bombylius, and a Muscid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 402).

In Dumfriesshire, Apis, a humble-bee, 2 short-tongued bees, and several Diptera have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 37).

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Helophilus pendulus *L.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Halictus cylindricus *F.* ♂, skg. (*b*) *Sphegidae*: 3. Cerceris variabilis *Schr.* ♀; 4. Oxybelus sericatus *Gerst.* ♀.

562. G. pyrenaicum. (Herm. Müller, 'Fertilisation,' p. 151, 'Alpenblumen,' pp. 173–4; Schulz, 'Beiträge,' II, p. 185; Knuth, 'Bloemenbiol. Bijdragen.')—For Central Germany, Hermann Müller describes the flowers of this species as agreeing with those of G. sanguineum. A. Schulz states that the female flowers are distributed gynodioeciously, or much more rarely gynomonoeciously.

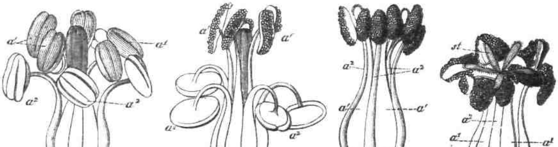

FIG. 67. *Geranium pyrenaicum*, *L.* (after Herm. Müller). (1) Stamens and pistil before the beginning of the first stage: all the anthers are still immature, and the undeveloped stigmas are in the middle of them. (2) The same in the first half of the first (male) stage: the outer stamens are erect, and their anthers are covered with pollen. (3) The same in the second part of the same stage. (4) The same in the second (hermaphrodite) stage: all the anthers are covered with pollen, and the stigmas are spread out. a^1 and a^2, anthers of the outer and inner stamens; *st*, stigmas; *n*, nectaries.

In the Alps, Herm. Müller ('Alpenblumen,' pp. 173–4) observed a variety with lilac petals, which spread out into a flat surface, and with stamens curving strongly outwards before dehiscence. The styles do not diverge till later on, so that automatic self-pollination is impossible.

VISITORS.—Herm. Müller observed 5 bees, nect-skg., 2 Syrphids, skg., and a Lepidopterid upon this Alpine form. I only saw the honey-bee in Schleswig-Holstein. Borgstette noticed the following—mostly bees and flies—in Central Germany.—

A. Coleoptera. (*a*) *Cistelidae*: 1. Cistela murina *L.* (*b*) *Dermestidae*: 2. Byturus fumatus *L.* (*c*) *Telephoridae*: 3. Malachius aeneus *L.* **B. Diptera.** (*a*) *Muscidae*: 4. Echinomyia fera *L.*; 5. Scatophaga stercoraria *L.* (*b*) *Syrphidae*:

6. Ascia podagrica *F.*; 7. Chrysotoxum bicinctum *L.*; 8. Helophilus floreus *L.*; 9. Melithreptus pictus *Mg.*; 10. M. taeniatus *Mg.*; 11. Pelecocera tricincta *Mg.*; 12. Rhingia rostrata *L.*; 13. Syrphus balteatus *Deg.*; 14. S. pyrastri *L.*; 15. S. ribesii *L.*: all skg. **C. Hymenoptera.** (*a*) *Apidae*: 16. Andrena dorsata *K.* ♀; 17. A. fulvago *Chr.* ♀; 18. A. gwynana *K.* ♀ and ♂; 19. A. parvula *K.* ♀; 20. Chelostoma nigricorne *L.* ♀; 21. Halictus cylindricus *F.* ♀; 22. H. maculatus *Sm.* ♀; 23. H. smeathmanellus *K.* ♀; 24. Osmia fusca *Chr.* ♀; 25. Sphecodes gibbus *L.* ♀: all skg. (*b*) *Sphegidae*: 26. Ammophila sabulosa *L.* (*c*) *Vespidae*: 27. Odynerus spinipes *L.*

MacLeod observed 5 Hymenoptera, 2 species of Bombylius, 2 species of Empis, and 2 Muscidae, in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 401). Loew saw the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., skg. (*b*) *Syrphidae*: 2. Syrphus pyrastri *L.*, hovering for a long time in front of a flower, and then skg. **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg.; 4. Bombus lapidarius *L.* ☿, do.; 5. Stelis phaeoptera *K.* ♀, do.

563. G. cinereum Cav.—MacLeod states that this Pyrenean species possesses thoroughly protandrous flowers (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 403–5). Their diameter—when fully expanded—is 3–3½ cm. The petals are dark violet with numerous violet veins. The stamens are at first curved outwards, with their anthers still closed. They then become erect, and the pollen is shed. After dehiscence, the stamens again curve outwards, and the stigmas unfold. Self-pollination is consequently prevented. Besides hermaphrodite flowers, MacLeod observed smaller female ones, distributed gynodioeciously. Their filaments, though devoid of anthers, executed the same movements as those of hermaphrodite blossoms. They even retain protandry, for the stigmas remain apposed until the flower has been open for some time. This arrangement, as MacLeod points out, is not merely useless but even injurious. For it exposes the stigmas and nectar for a while to wind and rain.

Visitors.—MacLeod observed bees (Bombus), Lepidoptera (Pyralidae), Syrphidae (Eristalis), Empidae, and, more particularly, Muscidae (species of Anthomyia).

564. G. phaeum L. (Ricca, 'Oss. sulla fecondaz. incroc. d. veget. alp. e subalp.'; MacLeod, 'Pyreneënbl.,' p. 130; Schulz, 'Beiträge,' II, p. 184; Kirchner, 'Flora v. Stuttgart,' pp. 336–7; Errera, 'Geranium phaeum'; Knuth, 'Bloemenbiol. Bijdragen.')—According to MacLeod, the dark reddish-brown or violet blossoms of this species are bee flowers. It is true that the nectar is not more deeply placed than in the other large-flowered species of geranium, but the blossoms are vertical, or even slightly pendulous. In consequence of this position, they can only be sucked by very skilful visitors, such as bees. Kirchner says that they are markedly protandrous. At the beginning of anthesis, the petals spread out to form a surface 22 mm. across, but soon recurve so much that the diameter is reduced to 18 mm., and the stamens and stigmas successively project freely. The nectaries are situated, as usual, outside the bases of the stamens which alternate with the petals. They are from the first protected from rain by the corolla, for though the claws of the petals are vertical the lower part of the limbs arches over the nectary to form a roof. The stamens mature successively, the inner ones first. At first they all curve towards the base of the flower, but when the anthers dehisce, the filaments straighten out, and project horizontally from the flower for about 10 mm. The anthers fall

off after they have shed their pollen, and the filaments bend back again to their original position. After all the anthers have dropped off, the styles—which at first project only about 7 mm. from the flower, and are close together—gradually grow to a length of 10–11 mm. and spread out, the five stigmatic branches being placed at the level which the anthers first occupied. After being pollinated, they come together again. Besides these distinctly protandrous flowers, Schulz—on garden plants—observed female ones, distributed gynodioeciously.

VISITORS.—Kirchner noticed numerous honey-bees at Hohenheim (Wurtemberg). I myself observed the same visitors at Kiel; they hang upon the stamens or styles in the manner described by Jordan.

MacLeod saw 4 humble-bees in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 405–6). Darwin mentions humble-bees; Ricca humble-bees and Apis; Plateau Eucera longicornis *L.*; and Errera 29 Hymenoptera.

Loew observed the following bees in the Berlin Botanic Garden.—

1. Apis mellifica *L.* ☿ (also the variety *lividum*), very freq., skg.; 2. Bombus hortorum *L.* ♀, skg.; 3. B. lapidarius *L.* ☿, do.; 4. B. rajellus *K.* ♀, do.; 5. Coelioxys elongata *Lep.* ♀, do.; 6. Halictus albipes *F.* ♀, do.

565. G. macrorrhizum L.—This species also, according to Jordan, has pendulous flowers that are visited in the same way as those of the last species. Hildebrand (Bot. Ztg., Leipzig, xxvii, 1869, pp. 479–81) states that it is equally protandrous; at first purely female flowers appear.

566. G. dissectum *L.* (Herm. Müller, 'Fertilisation,' p. 156, 'Weit. Beob.,' II, pp. 217–18; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 233; Kirchner, 'Flora v. Stuttgart,' p. 338; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—This species, unlike those hitherto dealt with, bears protogynous flowers, with very persistent stigmas. In the sunshine they open only far enough to be funnel-shaped, with an entrance 6–8 mm. The stigmas are mature, and their branches expanded when the flower opens, while the anthers which closely surround them are still unripe. Later on the anthers dehisce successively, covering the stigmas with pollen. Hermann Müller's researches show that this automatic self-pollination is effective. Insects visiting the flowers may effect self- as well as cross-pollination, but the visitors are very few.

Warnstorf describes the flowers as homogamous and autogamous; the stigmatic papillae are mature at the time when the anthers dehisce. The latter are blue in colour, and closely applied to the stigmatic branches, so that self-pollination is inevitable. The pollen-grains are bluish-white, spherical, densely tuberculated, cohering, with an average diameter of 63 μ.

VISITORS.—Herm. Müller observed in Thuringia only a bee—Andrena gwynana *K.* ♀ and ♂, skg.—and 2 Diptera—Occemyia atra *F.* and Merodon aeneus *Mg.*, both skg.

Schletterer saw the beautiful bee Osmia versicolor *Ltr.*, and the saw-fly Amasis laeta *F.*, at Pola.

MacLeod noticed a Lepidopterid and a fly in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 402).

In Dumfriesshire a hover-fly and 2 Muscids have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 39).

In this species again the access of creeping insects to the flowers is prevented by the glandular character of the calyx.

567. G. lucidum L.—Kerner states that the small flowers of this species are open from 7 a.m. to 8 p.m. Besides the protogynous hermaphrodite flowers—capable of self-pollination—there are female ones distributed gynomonoeciously.

VISITORS.—In Dumfriesshire 6 hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 38).

568. G. columbinum L.—Each of the bright rose-coloured petals of this species is marked with three dark veins that serve as nectar-guides. Kerner says that the flowers are open from 8 a.m. till 5 p.m. Their mechanism seems to vary, for while Kerner describes them as protogynous and autogamous, Schulz ('Beiträge,' II, p. 185) asserts that they are slightly protandrous. According to the latter there are female flowers as well as hermaphrodite ones, distributed gynodioeciously and gynomonoeciously.

569. G. rotundifolium L.—The flowers of this species studied by A. Schulz ('Beiträge,' II, p. 56) at Bozen, were red, and measured about 5–7 mm. across when expanded. Soon after anthesis the outer anthers mature, and the inner anthers do not dehisce as a rule until these have shed their pollen. The stigmas are at the same level as the anthers, and mature simultaneously, so that, failing insect-visits, automatic self-pollination is inevitable. Owing to the inconspicuousness of the

FIG. 68. *Geranium molle, L.* (after Herm. Muller). 1–5. Stamens and pistil in successive stages of development. *a*¹, *outer stamens, with nectaries at their bases*; *a*², *inner stamens*; *st*, *stigmas*.

flowers, and the small amount of nectar secreted, there are but few visitors. These may effect either self- or cross-pollination.

Protection against creeping animals is afforded by glandular hairs.

VISITORS.—Schulz saw occasional Diptera—mostly hover-flies, e.g. Rhingia—and 2 Lepidoptera (Lycaena).

F. F. Kohl observed the wasp Odynerus tarsatus *Sauss.* in the Tyrol.

570. G. molle L. (Sprengel, 'Entd. Geh.,' p. 338; Herm. Müller, 'Fertilisation,' pp. 153–4, 'Weit. Beob.,' II, p. 217; Kirchner, 'Flora v. Stuttgart,' p. 340; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 51, 'Blütenbiol. Notizen'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 230–3; Loew, 'Blütenbiol. Floristik,' p. 398; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The rose-coloured flowers of this species are slightly protandrous. When the flower opens, the stigmatic branches are apposed, so that their receptive parts are covered. The still immature anthers are directed outwards. The outer stamens now bend inwards in succession, their anthers resting on the pistil, and there dehiscing. As the top of the stigmatic

branches are still unreceptive, the flower is purely male at this stage. But, even before all the five outer anthers have dehisced, these branches begin to diverge. The outer stamens next bend towards the middle of the flower, and their anthers dehisce. In the final stage, the anthers stand between and somewhat above the stigmas, so that insect visitors may effect either cross- or self-pollination. In the absence of such visitors, automatic self-pollination necessarily occurs.

Warnstorf describes the flowers as homogamous and autogamous, and states that the pollen-grains are yellowish, spherical, covered with reticulately arranged tubercles, and about 63 μ in diameter.

At Blankenberge, besides the protandrous hermaphrodite flowers, MacLeod observed female ones with anthers devoid of pollen, and also intermediate forms, in which only some of the stamens were sterile.

VISITORS.—Hermann Müller observed the following.—

A. Diptera. (*a*) *Conopidae*: 1. Dalmannia punctata *F.*, skg.; 2. Myopa testacea *L.*, do. (*b*) *Muscidae*: 3. Scatophaga merdaria *F.*, skg. (*c*) *Syrphidae*: 4. Ascia podagrica *F.*, very freq., skg.; 5. Helophilus pendulus *L.*, skg.; 6. Rhingia rostrata *L.*, do.; 7. Syritta pipiens *L.*, do. **B. Hymenoptera.** (*a*) *Apidae*: 8. Andrena gwynana *K.* ♀, skg.; 9. Apis mellifica *L.* ☿, do.; 10. Chelostoma campanularum *K.* ♀, do. (Buddeberg); 11. Halictus nitidus *Schenck* ♀, do.; 12. H. sp., do.

On June 5, 1897, I saw the following in Helgoland.—1. Eucera difficilis (Duf.) *Pér.* ♂, skg.; 2. Lucilia caesar *L.*, do.; 3. Syritta pipiens *L.*, hovering for some time before the flower, then skg. and po-dvg.; 4. Andrena labialis *K.* ♂, skg.

H. de Vries in the Netherlands (Ned. Kruidk. Arch., 2. ser., 2. deel, Nijmegen, 1875) noticed a humble-bee, Bombus terrester *L.* ♀; and MacLeod observed 6 bees, 4 hover-flies, 2 Muscidae, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 232–3).

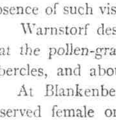

FIG. 69. *Geranium pusillum*, *L.* (after Herm. Müller). Stamens and pistil of a just opening flower. *a*, anthers; *st*, stigmas.

Loew ('Beiträge,' p. 60) saw the bee Melithreptus menthastri *L.* in Switzerland; while at Pola Schletterer observed a saw-fly, Cladius pectinicornis *Fourcr.*, and the following bees:—1. Andrena dubitata *Schenck*; 2. A. flavipes *Pz.*; 3. A. parvula *K.*; 4. Halictus calceatus *Scop.*; 5. Osmia versicolor *Ltr.*

In Dumfriesshire, a short-tongued bee, a hover-fly, and several Muscidae have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 39).

571. **G. pusillum** L. (Herm. Müller, 'Fertilisation,' pp. 154–5, 'Weit. Beob.,' II, p. 217; Kirchner, 'Flora v. Stuttgart,' p. 339; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 50–1.)—As Hermann Müller explains, the small lilac flowers of this plant are even less conspicuous than those of the last species, so that insect visitors are still less numerous, and automatic self-pollination constantly takes place before the end of anthesis. Although the flowers of the two species are externally very similar, their mechanisms are quite different. G. pusillum is protogynous, with persistent stigmas. Only the five inner stamens—those with nectaries at their bases—bear anthers. When the flower opens, the stigmatic branches have already half spread out, while the anthers lying between them are still immature. On dehiscence of the latter, the stigmatic branches diverge still more, and the stamens

bend towards the middle of the flower, so that the pollen-covered anthers lie above them. It follows that automatic self-pollination is effected by the fall of pollen, should insect-visits fail. Even after the anthers have dropped off, the stigmas remain receptive.

VISITORS.—Hermann Müller observed only a few Syrphidae.

572. G. Robertianum L. (Sprengel, 'Entd. Geh.,' p. 337; Herm. Müller, 'Fertilisation,' pp. 156–7, 'Weit. Beob.,' II, p. 218; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 229–30; Kirchner, 'Flora v. Stuttgart,' pp. 340–1; Schulz, 'Beiträge,' II, pp. 57–8; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller describes the flowers of this species as slightly protandrous. The petals are rose-coloured, with three paler streaks, and their claws remain erect, so that the flower does not open widely. The nectar collects in the slightly excavated bases of the sepals, and a proboscis 7 mm. long is required to reach it. When the flower opens the five inner stamens are in the middle of the flower, their anthers dehiscing at a somewhat higher level than the still apposed stigmatic branches, which consequently get covered with pollen. The five outer stamens are curved widely outwards. While the anthers of the five inner stamens still retain pollen, the stigmatic branches elongate and spread out above them. When, however, these stamens have shed their pollen, the five outer ones move towards the middle of the flower, and surround the styles. Insect-visits effect cross-pollination, at first owing to protandry, and later on because the fully mature stigmas project above the pollen-covered anthers. Self-pollination, however, is not excluded.

According to Schulz, the hermaphrodite flowers are occasionally homogamous. Besides these, unisexual ones occur, distributed gynodioeciously and gynomonoeciously, or androdioeciously and andromonoeciously.

Warnstorf describes the pollen-grains as large, spherical, closely tuberculated, and opaque, measuring 70 μ in diameter.

VISITORS.—Hermann Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) have observed the following in Central and North Germany.—

A. Coleoptera. (*a*) *Staphylinidae*: 1. Anthobium sp. (H. M.). (*b*) *Telephoridae*: 2. Dasytes flavipes *F.*, skg., and gnawing the petals. **B. Diptera.** (*a*) *Empidae*: 3. Empis sp., vainly searching for nectar (Budd.). (*b*) *Syrphidae*: 4. Rhingia rostrata *L.*, freq., skg. and po-dvg. (H. M., Budd.). **C. Hymenoptera.** *Apidae*: 5. Andrena gwynana *K.* ♂ (Budd.); 6. Bombus agrorum *F.* ☿, skg. (H. M.); 7. B. hortorum *L.* ☿, skg. persistently (H. M.); 8. B. lapidarius *L.*, skg. (Kn.); 9. B. terrester *L.*, do. (Kn.); 9. Chelostoma campanularum *K.* ♂, do. (Budd.); 10. C. nigricorne *Nyl.* ♂, do. (Budd.); 11. Halictus cylindricus *F.* ♀, do. (H. M., Thuringia); 12. Osmia adunca *Pz.* ♂, do. (Budd.); 13. O. rufa *L.* ♀, do. (Budd.). **D. Lepidoptera.** *Rhopalocera*: 14. Pieris napi *L.*, freq., skg. (H. M.).

Krieger noticed the following *Apidae* at Leipzig.—1. Anthidium manicatum *L.*; 2. Andrena gwynana *K.*, 1st generation; 3. Coelioxys rufescens *Lep.*; 4. Eriades nigricornis *Nyl.*; 5. Osmia caerulescens *L.* (=O. aenea *L.*); 6. O. solskyi *Mor.*; 7. Stelis phaeoptera *K.*

Hermann Müller further saw 4 humble-bees, 2 hover-flies, and 3 Lepidoptera in the Alps.

Willis observed a Syrphid (Syrphus sp., skg.), a bee (Bombus agrorum *F.*, freq., skg.), and a butterfly (Pieris napi *L.*, skg.), in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).

In Dumfriesshire, 2 humble-bees, 2 Empidae, several Muscidae, a Lepidopterid, and Meligethes have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 38).

MacLeod observed 4 bees, 4 Lepidoptera, and a Muscid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 402); and a humble-bee, an Empis, a wasp, and a Lepidopterid in Flanders (op. cit., vi, 1894, p. 230).

573. **G. rivulare** Vill.—According to Briquet ('Études de biol. flor. dans les Alpes occident.'), the flowers of this species are protandrous to such a degree, that automatic self-pollination can only occur exceptionally. The petals are white, each with red veins. The yellow anthers, after dehiscing, become extrorse, and assume a violet colour. The bases of the filaments are beset with hairs, which serve to protect the nectar.

VISITORS.—These are Diptera, Hymenoptera, and butterflies (Kirchner).

According to the observations of Loew, in the Berlin Botanic Garden, the following species of Geranium are visited as stated.—

574. **G. albanum** Bieb.; a Muscid, *skg.*

575. **G. Arnottianum** Steud.; the honey-bee, skg.

576. **G. ibericum** Cav.—

A. Diptera. *Syrphidae*: 1. Helophilus pendulus *L.* **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg.; 3. Bombus lapidarius *L.* ☿, skg. (also, on the var. *platypetalum*, Apis mellifica and Prosopis communis *Nyl.* ♀).

577. **G. Pseudosibiricum** J. Meyer; the honey-bee, skg.

578. **G. reflexum** L.; do.

579. **G. rubellum** Moench.—Two bees—Coelioxys elongata *Lep.* ♀, skg., and Osmia aenea *L.* ♀, do.

580. **G. ruthenicum** Uechtritz; a bee—Halictus cylindricus *F.* ♂, skg.

581. **G. sibiricum** L.; a Muscid—Anthomyia sp.—skg.

582. **G. striatum** L.; bees—Apis and Halictus leucozonius *Schr.* ♂—skg.

172. Erodium L'Hérit.

Protandrous, homogamous, or protogynous flowers, with concealed nectar, secreted as in the last genus. The petals are frequently dissimilar, the lower ones being longer. Stamens ten, the five opposite the petals broader than the others, and devoid of anthers, while those alternating with the petals bear anthers and possess nectaries at their bases.

583. **E. cicutarium** L'Hérit. (Sprengel, 'Entd. Geh.,' pp. 338–40; Herm. Müller, 'Fertilisation,' pp. 158–9; Ludwig, Kosmos, Leipzig, viii, 1881, pp. 357–62, Irmischia, Sondershausen, ii, 1881, pp. 5–7, Bot. Centralbl., Cassel, viii, 1881, pp. 87–8, *D. bot. Monatschr., Arnstadt, i, 1883, pp. 5–7, Bot. Centralbl., Cassel,* xix, 1884, p. 118; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 234–7; Schulz, 'Beiträge,' II, pp. 58–9, 185; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 51–3, 152; Kirchner, 'Flora v. Stuttgart,' pp. 341–2; Loew, 'Blütenbiol. Floristik,' p. 212; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Sprengel has given an admirable account of the flower mechanism. F. Ludwig was the first to

call attention to the differences between the two varieties of this species as regards pollination. He distinguishes between them as follows.—

(*a*) *Genuinum.*—The petals of this, the common variety, are generally of a uniform red, and equal in size, though the upper ones are sometimes rather shorter and of a darker tint than the others. The nectaries are all equally developed, as in Geranium. The flowers are homogamous or slightly protogynous. The three upper anthers, while dehiscing, lie close to the stigmatic branches, as do the two lower ones subsequently, so that automatic self-pollination is inevitable. This is effected an hour after the flower opens, which is at 7 o'clock in the morning. By midday the flowers have shed their petals. This variety is perfectly fertile with its own pollen.

(*b*) *Pimpinellifolium* Willd.—This variety is markedly entomophilous. The flowers are as a rule relatively large, and the two upper petals smaller, broader, and of a brighter red than the three lower ones. The latter are elongated, and serve as an alighting-place for visitors. Each upper petal generally has a dark nectar-guide, but this may be absent, and some or all of the other petals may be similarly provided. The deeper parts of the flower are at first so blocked up by the stamens that no insects can penetrate into them. The upper sepal and petals are so far remote from the upper stamens that the dark posterior nectaries become visible, while the lower ones are almost hidden by the hairs of the petals. The latter are distinctly smaller than the former, and secrete much less nectar. When the flower opens the style is still short and undeveloped, and the anthers are at some distance from it. First the upper anthers, and afterwards the lower ones, dehisce introrsely. The stamens soon curve completely outwards, and usually shed their anthers before the stigmatic branches open and expand, which is generally on the second day of anthesis. Only occasionally, especially when the nectar-guides are not very conspicuous, do the stamens bend back again to the stigma in such a way as to make automatic self-pollination possible as a last resort; but this is effective only to a slight extent. The petals usually fall off on the second day. The nectar-guides are frequently wanting, or only slightly developed, in the smaller female flowers that occur in addition to the hermaphrodite ones, either on the same or on different stocks.

The variety *pimpinellifolium*, however, does not always exhibit the characteristics described by Ludwig[1]. Schulz, in various parts of Germany and the Tyrol, has studied the varieties of Erodium cicutarium for several years. The chief variety (*genuinum*), according to him, occurs—e. g. at Halle—in two different oecological forms.

1. Flowers of a uniform red, in many cases quite radially symmetrical (actinomorphous), and with a diameter of about 8 to 13 mm. Sometimes the two upper petals are short and broad, sometimes they are also more deeply coloured than the upper ones, and may exhibit one or several greyish-white patches, occasionally streaked with red. Such flowers are almost always homogamous, less often slightly

[1] Ludwig described *genuinum* from the neighbourhood of Greiz, and *pimpinellifolium* from Schmalkalden, Schleusingen, &c.

protandrous, very rarely protogynous. As a rule, self-fertilization alone takes place in this form. Insect-visits are extremely rare, even when nectar-guides are present.

2. Flowers usually bilaterally symmetrical (zygomorphous) to a marked degree, and very large, their diameter being 12–15 mm. Nectar-guides may be present, and if so are clearly marked, moderately large, often nearly bisected by the mid-ribs, and covered with numerous dark streaks and dots. The flowers are markedly protandrous, and self-pollination is usually excluded.

Schulz says that, at Halle, the flowers of *pimpinellifolium* are almost always larger than the average of those borne by *genuinum*, bilaterally symmetrical as a rule, and possessed of nectar-guides, though more rarely they are radially symmetrical, in which case the petals may be blotched or unblotched. They are almost always protandrous, but homogamy may occur sporadically. In many cases the plant is entirely dependent on cross-pollination.

In the south Tyrol, Schulz found only *genuinum*, mostly with unblotched homogamous flowers, presenting perfect or almost perfect radial symmetry. Elsewhere he also saw the large-flowered form of this variety growing together with *pimpinellifolium*; the flowers of both were visited by insects to the same extent. With a pipette, Schulz carefully removed every trace of nectar from the nectaries of a number of newly-opened flowers of *pimpinellifolium*, and smeared the glands with shellac.

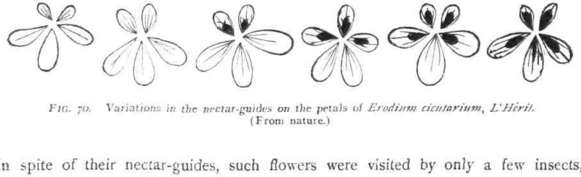

FIG. 70. Variations in the nectar-guides on the petals of *Erodium cicutarium*, *L'Hérit.* (From nature.)

In spite of their nectar-guides, such flowers were visited by only a few insects, while neighbouring blossoms — both those of *genuinum*, and untouched ones of *pimpinellifolium*—received, just as before, a considerable number of visits. Here again, the odour of the nectar serves as the chief means of attracting the insects, the nectar-guides being of secondary importance in this respect, except when very brightly coloured, and therefore conspicuous by contrast.

At a time when unacquainted with Schulz's work, I arrived at similar conclusions while studying the variation of the nectar-guides of Erodium cicutarium in the North Frisian Islands. The flower is here markedly protandrous, and always bilaterally symmetrical, the upper petals being shorter, broader, and of deeper hue than the lower ones. The nectar-guides are developed to a very varying extent; in some flowers they have all but disappeared, in others they are very conspicuous. But in all cases the insect visitors are the same, and blossoms which possess well-marked nectar-guides are by no means more sought out than those almost lacking them. Insects fly from one kind of flower to another without their selection being influenced by the degree of prominence of the nectar-guides. This is noteworthy, it being generally assumed that the guides indicate the position of the nectar to insects, which in flowers without such markings, either do not find, or do not suspect the

presence of, the desired secretion. When, however, insects have once found the nectar in a flower possessing guides, it is easy for them to discover it in flowers of the same species devoid of guides. But the various flower-forms of Erodium cicutarium somewhat limit Sprengel's theory of nectar-guides ('Entd. Geh.,' pp. 15, 16), since they show that these—though helping insects to find nectar—are not absolutely necessary, it being sufficient if a certain number of blossoms possess them.

Loew summarizes as follows the results he obtained by studying the flower-pollination of Erodium cicutarium ('Blütenbiol. Floristik,' p. 212).—The absence or presence of nectar-guides is not an essential distinction between the autogamous and allogamous varieties, nor are these markings restricted—as Ludwig maintained—to *pimpinellifolium*. Both great varieties of the species present various stages between allogamy and autogamy, differing chiefly in their feebler or stronger protandry, smaller or larger flowers, and possession of actinomorphy or zygomorphy.

Besides the hermaphrodite flowers, Schulz has observed unisexual ones, distributed gynodioeciously and gynomonoeciously, or androdioeciously and andromonoeciously.

Warnstorf describes the flowers as protogynous, and adds the following.—The stamens are shorter than the styles, so that self-pollination is prevented. In the small-flowered variety (at Ruppin) the petals are usually not blotched at the base, but the two upper ones, which are smaller and of a deeper red than the others, frequently have the yellowish basal blotch that is characteristic of the large-flowered variety. In the latter there may be, though rarely, three to four blotched petals. In the smaller flowers the stamens are often vestigial, so that female stocks occur. The stigma is purple, rose-coloured, or pale yellow.

VISITORS.—Sprengel saw humble-bees and the honey-bee. In the island of Röm, I noticed a hover-fly (Helophilus pendulus *L.*), remarkably freq., and I have seen other hover-flies in Föhr and at Kiel, as well as short-tongued bees.

Herm. Müller gives the following list.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella septempunctata *L.*, nect-lkg. **B. Diptera.** (*a*) *Conopidae*: 2. Myopa buccata *L.*, skg. (*b*) *Muscidae*: 3. Calliphora vomitoria *L.*, skg.; 4. Lucilia cornicina *F.*, do.; 5. L. sp., do. (*c*) *Syrphidae*: 6. Rhingia rostrata *L.*, skg.; 7. Syritta pipiens *L.*, do. **C. Hymenoptera.** (*a*) *Apidae*: 8. Andrena gwynana *K.* ♀, skg. (Thuringia); 9. A. parvula *K.* ♀, do.; 10. Apis mellifica *L.* ☿, skg. and po-cltg.; 11. Halictus cylindricus *F.* ♀, skg.; 12. H. leucozonius *Schr.* ♀, do.; 13. H. nitidiusculus *K.* ♀, do.; 14. Sphecodes ephippius *L.*, do. (*b*) *Sphegidae*: 15. Ammophila sabulosa *L.*, skg. **D. Lepidoptera.** *Rhopalocera*: 16. Pieris napi *L.*, skg. persistently; 17. P. rapae *L.*, do.

Verhoeff observed the following in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes aeneus *F.*, po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp.; 3. Miltogramma sp., po-dvg. (*b*) *Syrphidae*: 4. Melithreptus menthastri *L.* **C. Hymenoptera.** (*a*) *Chrysididae*: 5. Holopyga amoenula *Dahlb.* (*b*) *Pteromalidae*: 6. Pteromalus sp. (*c*) *Sphegidae*: 7. Oxybelus uniglumis *L.*, skg.

Loew saw Apis mellifica *L.* ☿, skg., in Silesia ('Beiträge,' p. 25); as did also H. de Vries in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875). MacLeod observed Apis, a humble-bee, 2 short-tongued bees, 3 hover-flies, 3 Muscidae, and a Lepidopterid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 236–7).

Schletterer noticed the following bees at Pola:—1. Andrena ventricosa *Dours.* ♀; 2. Ceratina cucurbitina *Rossi*; 3. Halictus calceatus *Scop.*

In Dumfriesshire 3 Muscidae have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 37).

Ludwig saw some *Apidae*, 2 ichneumons, 5 bees, and the following flies, visiting the variety *pimpinellifolium* (D. bot. Monatschr., Arnstadt, i, 1883).—

(*a*) *Syrphidae*: 1. Syrphus pyrastri *L.*; 2. S. cinctellus *Zett.*; 3. S. lineola *Zett.*; 4. S. corollae *F.*; 5. S. balteatus *Deg.*; 6. S. arcuatus *Fall.*; 7. Eristalis sepulcralis *L.*; 8. Syritta pipiens *L.*; 9. Melithreptus scriptus *L.*; 10. M. pictus *Mg.*; 11. M. taeniatus *Mg.*; 12. Melanostoma mellina *L.*; 13. M. gracilis *Mg.*; 14. Ascia podagrica *F.*; 15. Xylota segnis *L.*; 16. Platycheirus albimanus *F.*; 17. P. scutatus *Mg.*; 18. P. clypeatus *Mg.*; 19. P. fasciculatus *Loew*; 20. Lucilia caesar *L.*; 21. L. sylvarum *Mg.* (*b*) *Muscidae*: 22. Anthomyia radicum *L.*; 23. Spilogaster duplicata *Mg.*; 24. Chortophila cilicrura *Rond.*; 25. C. dissecta *Mg.*; 26. C. floccosa *Mg.*

584. E. malachoides Willd.—

Visitors.—Schletterer observed the bee Halictus calceatus *Scop.* at Pola.

585. E. gruinum Willd. (Ludwig, Bot. Centralbl., Cassel, viii, 1881, pp. 357–62.)—Ludwig states that this South European and North African species bears large blue protogynous flowers, exhibiting radial symmetry, and having a diameter of 28 mm. The stamens at first curve outwards, subsequently bending inwards, so that self-pollination may ultimately be effected.

586. E. macradenum L'Hérit. (Ludwig, op. cit., viii, 1881, pp. 87–88.)—Ludwig says that the flowers of this Pyrenean species are so markedly protandrous that self-pollination is prevented. Each of the two upper petals possesses a large and conspicuous nectar-guide. Ludwig also states that the species is adynamandrous.

587. E. Gussoni Tenore.—This small-flowered South European species is very nearly homogamous.

588. E. Manescavi Coss.—Ludwig states that the petals of this Pyrenean species are of a purple-violet colour, with darker veins, while the upper one possesses a basal nectar-guide. The anthesis of the protogynous flowers lasts from $1\frac{1}{2}$ to 3 days, and the species is in bloom for four months.

Both autocarpy and allocarpy obtain to a certain extent. Out of forty-four flowers pollinated from the same stock, twenty-six set fruits, but only 4 % of these ripened.

589. E. moschatum L'Hérit.—Ludwig says that the short-lived inconspicuous purple flowers of this species are either homogamous, or slightly protogynous.

590. E. maritimum L'Hérit.—According to Ludwig this species is sometimes pseudo-cleistogamous.

2. Tribe Pelargonieae.

173. Pelargonium L'Hérit.

According to Hildebrand (Bot. Ztg., Leipzig, xxvii, 1869, pp. 479–81), some species of this genus are protandrous, while the first flowers are purely female.

591. P. triste L.—The greenish flowers of this species exhale a strong odour at night.

Visitors.—During the day Plateau only saw a small Muscid. The time when the flowers are odorous suggests that they are probably pollinated by nocturnal insects.

592. **P. zonale** L'Hérit.—Darwin states that this species is self-sterile.

174. Tropaeolum L.

Protandrous hymenopterid flowers, the spurred calyx of which secretes and conceals nectar.

593. **T. majus** L. (Sprengel, 'Entd. Geh.,' pp. 213–27; Delpino, 'Sugli appar. d. fecondaz. nella piante autocarp.,' p. 30; Knuth, 'Bloemenbiol. Bijdragen.')—This species bears markedly protandrous humble-bee flowers. There is a red blotch, serving as a nectar-guide, on the base of the lamina of each yellow petal. When the flower opens, the stamens are all curved downwards, with anthers still unripe, the style is still very short, and the stigmas are closely apposed. Now one stamen

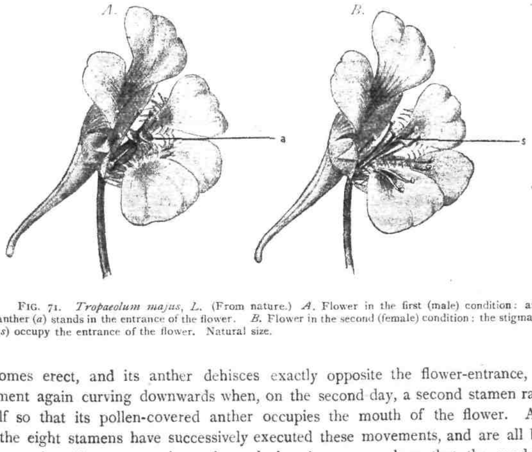

Fig. 71. *Tropaeolum majus, L.* (From nature.) *A.* Flower in the first (male) condition: an anther (*a*) stands in the entrance of the flower. *B.* Flower in the second (female) condition: the stigmas (*s*) occupy the entrance of the flower. Natural size.

becomes erect, and its anther dehisces exactly opposite the flower-entrance, the filament again curving downwards when, on the second day, a second stamen raises itself so that its pollen-covered anther occupies the mouth of the flower. After all the eight stamens have successively executed these movements, and are all bent downwards with empty anthers, the style has become so long that the gradually maturing stigmas take up the position previously assumed by the dehiscing anthers. An insect visiting one of the younger flowers in search of nectar, will therefore dust the under-surface of its body with pollen, and when subsequently visiting older flowers will necessarily transfer some of this to the stigmas.

Visitors.—Sprengel observed an ant (in the spur), also small spiders ('which presumably chase the little insects that creep into the flowers'), and a fly ('which,

however, was not adapted to effect fertilization, for the lazy and stupid insect mistook the nectar-cover for the nectar-reservoir, and thrust its proboscis into it to find, as it had been raining, only drops of water').

In Schleswig-Holstein, Mecklenburg, Pomerania, and Thuringia, I observed Bombus hortorum *L.*, also the variety *nigricans* Schmiedekn., skg., and spending some seconds in each flower. The spur is 25 mm. long, so that the proboscis of this humble-bee—being only 21 mm. in length—would not reach its tip, but the entrance to the spur is so wide, that the insect can push its head 5 mm. down the tube, and thus easily exhaust its contents. The garden humble-bee is, therefore, a regular fertilizer of the species. Besides this insect, I once saw an earwig (Forficula auricularia) half-buried in the spur, and remaining there so persistently that I was able to pluck the flower, and observe its behaviour. It was evidently able to get some of the nectar that filled the spur to an unusual height. A third visitor that I observed was Apis mellifica *L.* ☿. This first penetrated as far as possible into the spur, and then made vain efforts to suck. When it did not succeed in getting nectar in sufficient quantity, it proceeded to collect pollen, and, taught by experience, made no more fruitless attempts at sucking. Alfken saw Bombus hortorum *L.* ♂, skg., at Bremen.

594. **T. minus** L. (Knuth, 'Bloemenbiol. Bijdragen.')—Like the last species, this plant is a native of Peru, and its flower mechanism is very similar. The spur, however, is usually considerably longer, i.e. 25–35 mm. None of our German humble-bees or bees are able therefore to reach to the ends of the longest spurs, even by thrusting in their head, which is about 5 mm. in length. One stamen after another becomes erect, placing its pollen-covered anther in the entrance of the flower, and after shedding its pollen again bending back against the corolla. When all the anthers have dehisced, the three-lobed stigma occupies the entrance of the flower, so that it is touched by nectar-sucking visitors. The three lower petals are fringed on their inner surface, so as to prevent visitors from forcing their way into the lower part of the flower. They are therefore compelled to seek the entrance to the spur, from above the upwardly dehiscing anther, or the stigma.

3. Tribe Oxalideae DC.

This tribe is represented by the genus

175. Oxalis L.

(*H. von Mohl, Bot. Ztg., Leipzig, xxi, 1863;* Hildebrand, Abh. Ak. Wiss., Berlin, 1866, Bot. Ztg., Leipzig, xxix, 1871, 'Die Lebensverhältnisse der Oxalis-Arten,' Jena, 1884.)

Flowers homogamous, with half-concealed nectar secreted in their bases.

While the three German species appear in only one form, a large number of foreign species are trimorphous or dimorphous. Experiments in artificial fertilization made by Hildebrand with trimorphous species, confirm the law established by Darwin for dimorphous plants, and for Lythrum Salicaria, i.e. that there is greatest fertility with legitimate fertilization. In some species (including O. Aceto-

sella), cleistogamous flowers have been observed. Our three native species agree almost completely in their flower mechanisms.

595. O. Acetosella L. (Herm. Müller, 'Fertilisation,' p. 159; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 237–8; Kirchner, 'Flora v. Stuttgart,' pp. 342–3; Knuth, 'Grundriss d. Blütenbiol.,' p. 39.)—Kerner states that the chasmogamous flowers are open from 9 a.m. till 6 p.m. Their white petals are streaked with longitudinal violet veins that serve as nectar-guides, and are also marked with a yellow basal spot immediately above the nectaries. The nectar collects in five depressions in the base of the corolla. These are formed by fleshy appendages of the claws of the five petals, reaching as far as the filaments. The length of the style being variable, the stigma may either project beyond the anthers, or be situated in the middle of them.

Hugo von Mohl (Bot. Ztg., Leipzig, xxi, 1863) was the first to describe the cleistogamous flowers. (Cf. Vol. I, pp. 51–2.)

Visitors.—These are rare. Alfken saw Apis and Bombus terrester *L.* ♀, at Bremen.

Herm. Müller observed the following.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes, freq. (*b*) *Staphylinidae*: 2. Omalium florale *Payk.*, freq. **B. Thysanoptera.** 3. Thrips, freq. He also noticed 7 Diptera, an ant, and Thrips in the Alps ('Alpenblumen,' pp. 178–9).

In Dumfriesshire a Muscid has been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 40).

Burkill observed the Nitidulid Meligethes picipes *Sturm*, and Thrips sp. on the coast of Yorkshire ('Fertilsn. of Spring Fls.').

596. O. stricta[1] L. (Kirchner, 'Flora v. Stuttgart,' p. 343; Schulz, 'Beiträge,' I, p. 31; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 391.)—Kerner says that the bright yellow flowers of this species are open from 8 a.m. till 4 p.m. The flower mechanism is very similar to that of the last species, but, according to Schulz, the anthers of the longer stamens are at the same level as the stigma—which matures simultaneously—and applied to it in such a way that automatic self-pollination is inevitable. The shorter stamens serve for cross-pollination. Kerner states that the flowers remain closed in bad weather. Cleistogamous flowers have not hitherto been observed.

Visitors.—MacLeod observed Apis, 2 hover-flies, and 2 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 238).

597. O. corniculata L.—The flower mechanism of this species completely agrees with that of O. stricta. And here too, according to Kerner, the flowers remain closed in bad weather, fertilizing themselves pseudo-cleistogamously.

598. O. cernua Thunb.—This species has been introduced into Sicily and Sardinia, where, according to Nicotra ('Oss. antobiol. sull' Oxalis cernua'), it is always microstylous, which explains its sterility in those islands. Stigmatic papillae

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[1] [In the Index Kewensis, *O. stricta* L. is given as a synonym of *O. corniculata* L.—Tr.]

can scarcely be said to exist. The pollen-grains are not homogamous. As the shorter stamens grow more rapidly than the style, the stigmas are often seen to be covered with pollen, but this apparently does not lead to autocarpy. Nicotra also observed cleistogamous flowers, or at least transition-forms towards such, and these perhaps now and then set fruits.

4. Tribe Balsamineae.

176. Impatiens L.

Markedly protandrous bee flowers, or more rarely hover-fly flowers. The nectar is secreted in the end of the calyx-spur. Some species (including I. Noli-tangere), especially North American ones, occasionally possess cleistogamous flowers, according to Hugo von Mohl (Bot. Ztg., Leipzig, xxi, 1863). Von Mohl's description of these is given in Vol. I, pp. 52–3. Some North American species of the genus are visited by humming-birds.

599. I. Noli-tangere L. (Kirchner, 'Flora v. Stuttgart,' pp. 346–7; Knuth, 'Grundriss d. Blütenbiol.,' pp. 38–9, 'Bloemenbiol. Bijdragen.')—In the large pendulous flowers of this species, which are golden-yellow, dotted with red in the throat, the united anthers of the five stamens are situated on the upper lip, and surround the stigma. When the flower opens, the anthers have dehisced, so that a humble-bee after getting at the nectar must carry away pollen on its back. At a later stage the stamens separate and the stigma matures, assuming the position previously occupied by the anthers. Automatic self-pollination, by pollen that remains clinging to the anthers, is possible.

Visitors.—I saw at Eutin two species of humble-bee skg., Bombus lapidarius *L.* ♀ and ♂, and B. hortorum *L.* ♀ and ♂ (also the variety *nigricans* Schmiedekn.). I further noticed a wasp—Vespa media *Retz.* ☿—at work on the flowers, and it seemed to reach the deeply concealed nectar. At Flensburg I also saw a humble-bee—Bombus terrester *L.*—which, however, was unable to completely empty the spur. In Central Germany, Herm. Müller also saw humble-bees, without being able, however, to determine their species. Loew noticed a small bee, Halictus cylindricus *F.* ♀, po-cltg., and, at the same time, incidentally effecting cross-pollination. As unbidden guests, Herm. Müller observed a species of Halictus (H. zonulus *Sm.* ♀), 2 beetles (Meligethes and Dasytes flavipes *F.*), and a fly (Sargus cuprarius *L.* ♂).

Hermann Müller ('Alpenblumen,' p. 179) found the flowers in Prättigau frequently perforated by Bombus mastrucatus *Gerst.*, and remarks that the flower there probably often has recourse to automatic self-pollination, its capacity for which was demonstrated by Darwin ('Cross- and Self-Fertlsn.,' p. 367).

600. I. parviflora DC. (Bennett, 'On the Floral Structure of Impatiens fulva *Nutt.*'; Henslow, 'On the Self-fertilisation of Plants'; Knuth, 'Bloemenbiol. Bijdragen.')—The small, bright yellow flowers of this plant possess the same flower mechanism as the last species, but, according to Henslow, automatic self-pollination is favoured. Bennett states that cleistogamous flowers do not occur.

Visitors.—In the Kiel Botanic Garden I observed no bees, but repeatedly saw a small hover-fly, Syrphus balteatus *Deg.*, which sucked persistently, and constantly visited several flowers in succession.

On September 10, 1897, I noticed ('Blütenbiol. Notizen') hover-flies, almost exclusively Syrphus corollae *F.*, in the Kiel Ober-Realschule Garden. This insect first hovers in the sunshine in front of the flower, approaches to within a few millimetres, again hovers a little further away, and repeats this sport several times till finally it settles down to suck, and to devour pollen. I also observed Syrphus ribesii *L.*, the same morning, visiting the flowers several times, while Apis avoided them, flying between the inflorescences and steadily visiting the flowers of Sedum maximum. I therefore regard I. parviflora as a hover-fly flower, not as a bee flower or humble-bee flower, like the other cultivated species.

The insect visitors of the species are generally very few, but as in spite of this all the flowers set fruits, it must be assumed that the plant is self-fertile.

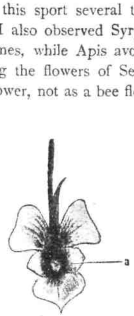


Fig. 72. *Impatiens parviflora, DC.* (From nature.) Flower seen from the front. *a*, anthers.

601. I. Balsamina L. (Sprengel, 'Entd. Geh.,' p. 400; Hildebrand, Bot. Ztg., Leipzig, xxv, 1867; Delpino, 'Sugli appar. d. fecondaz. nelle piante autocarp.,' pp. 30–1.)—The mechanism of the flower of this species agrees with that of I. Noli-tangere. In younger flowers the visitors are dusted with pollen, which they transfer to the stigmas of older ones, in which the stamens have already dropped off.

Visitors.—These are bees (humble-bees). Prunet (Rev. gén. Bot., Paris, iv, 1892) observed numerous insects, especially Apis, Bombus hortorum *L.*, B. terrester *L.*, and Polistes gallica *L.*

602. I. glanduligera Lindl. (=I. Roylei *Walp.*). (Delpino, 'Ult. Oss.,' II; Hildebrand, Bot. Ztg., Leipzig, xxv, 1867; Stadler, 'Beiträge'; Loew, Bot. Jahrb., Leipzig, xiv, 1891, pp. 166–82; Knuth, 'Bloemenbiol. Bijdragen.')—This commonly cultivated East Indian species bears well-marked humble-bee flowers. The large markedly protandrous purple-red blossoms have a short spur, and are of such a size that the body of a humble-bee just finds sufficient room in them. These insects, when visiting flowers in the first stage, get their backs dusted with pollen by contact with the anthers, and when visiting flowers in the second stage, they brush the stigma with the same part of the body. They disappear altogether in the blossoms when sucking nectar from the short blunt spurs, and leave flowers in the male condition with a streak of pollen 1–3 mm. in length on their backs.

This view of the flower mechanism, represented in my figure, is also taken by Delpino and Hildebrand. Though Loew does not dispute the possibility of such a mechanism, it does not appear to him to be the normal one indicated by the structure of the flowers. He points out the remarkable stigma-like structure of the ligules springing from the bases of the filaments, the bringing together of these in a narrow space readily accessible from the front, the position of this space at the most anterior point of the androecium immediately above the surface where

the pollen is shed, and lastly the occurrence of a mass of germinating pollen-grains on the upper surface of the closed stigma. All these facts, in Loew's opinion, lead to the conclusion that the cleft between the anterior stamens is a 'pollinating chamber,' while the ligular tips are 'pseudo-stigmas, or pollen-catchers.' When, for example, a humble-bee of suitable size—Bombus agrorum *F.*, and B. terrester *L.*, on the Peacock Island at Potsdam—flies to the wide opening of the flower, it first alights on the under-lip, the lateral teeth serving as points by which to hold on. It then tries to thrust its head under the sexual apparatus that hangs down from the roof of the flower-entrance, so as to penetrate into the wide sac-like sepal that secretes nectar at its end. When pressing its head against the androecium, it probably pushes forward a little the end of the contained stigma, which is directed obliquely to the front, and with the stigma it moves the pollen-catchers (i. e. the ligules). But even without this assumption, a humble-bee must in many cases, when pressing against the anterior margin of the androecium, introduce its prominent cephalic hairs into the cleft, so as to come into contact with the top of the pistil. When in this way a bee brings pollen from a flower previously visited, this pollen will be retained by the funnel-shaped ligular cap, and will germinate on the stigmatic surface at the top of the ovary. The fact that the stigma of I. Roylei remains closed, the ligular cap obviously occupying its place, lends special probability to this interpretation.

Loew also observed a dwarf-flower, intermediate in character between chasmogamous and cleistogamous blossoms. Actual cleistogamous flowers, such as have

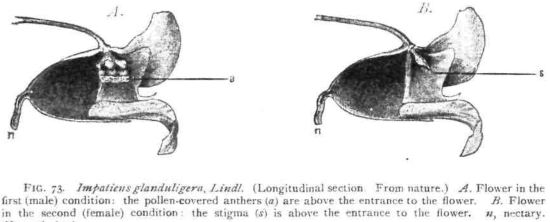


FIG. 73. *Impatiens glandulígera, Lindl.* (Longitudinal section. From nature.) *A.* Flower in the first (male) condition: the pollen-covered anthers (*a*) are above the entrance to the flower. *B.* Flower in the second (female) condition: the stigma (*s*) is above the entrance to the flower. *n*, nectary. (Natural size.)

been described for numerous species of this genus, have not hitherto been noticed in I. Roylei.

VISITORS.—In the Kiel Botanic Garden I observed the following 3 humble-bees, all very freq., skg.—1. Bombus agrorum *F.* ♀ and ♂; 2. B. lapidarius *L.* ♂; 3. B. terrester *L.* ♀ and ♂. I also noticed Apis mellifica *L.* ☿, which readily touches the anthers or stigma with its dorsal surface when entering or leaving the flower. It can therefore effect cross-pollination.

603. I. latifolia L.—According to Loew (op. cit.), this species bears lepidopterid flowers, possessing stigmas that are not covered, but project in the form of thin, feebly lobed membranous lamellae.

XXVI. ORDER *RUTACEAE* JUSS.

1. TRIBE RUTEAE.

LITERATURE.—Knuth, Grundriss d. Blütenbiologie, p. 39; Urban, Jahrb. bot. Gart., Berlin, ii, 1883, pp. 366–404.

The species of the genus Ruta bear nauseous flowers, which, by their penetrating odour and dull yellow colour, attract Hymenoptera, and particularly Diptera that are fond of putrid matter. On the other hand, the species of Dictamnus are visited by Apidae. Owing to their marked protandry, cross-pollination results in the species of both genera from insect-visits.

177. Ruta Tourn.

Flowers with exposed nectar, secreted by a fleshy disk beneath the ovary.

604. R. graveolens L. (Sprengel, 'Entd. Geh.,' p. 236; Herm. Müller, 'Fertilisation,' pp. 160–2, 'Weit. Beob.,' II, p. 213; Schulz, 'Beiträge,' II, pp. 59, 60; Kirchner, 'Flora v. Stuttgart,' p. 348; Knuth, 'Blütenbiol. Herbstbeob.')—As Hermann Müller justly remarks, the flower-mechanism of this species is very like that of Parnassia palustris, for the stamens first of all ripen successively, and then the stigma matures. The transfer of pollen is secured in both by the fact that the middle of the flower, which offers the most convenient alighting-place, is occupied first by a dehisced anther, and afterwards by the stigma. Finally, in both, the exposed nectar attracts similar guests (flies and short-tongued Hymenoptera), but while the white flowers of Parnassia are also visited by beetles, the dull yellow flowers of Ruta are not.

There is, however, this difference. In Ruta, according to Urban, all the stamens once more curve upwards before the stigma withers, so that should the anthers retain any pollen this falls upon the stigma, and thus renders automatic self-pollination possible towards the end of anthesis. Schulz, however, states that autogamy is impossible.

VISITORS.—Hermann Müller (H. M.) in Westphalia, Buddeberg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein, have observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia obelisca *Mg.*, skg. and po-dvg. (Winnertz); 2. A. pratensis *Mg.*, do. (Winnertz); 3. A. radicum *L.*, do. (Winnertz); 4. Calliphora erythrocephala *Mg.*, do. (Kn., H. M.); 5. Lucilia caesar *L.*, do. (Kn.); 6. L. cornicina *F.*, do. (H. M.); 7. L. sylvarum *Mg.*, do. (H. M.); 8. Pollenia rudis *F.*, do. (H. M.); 9. Sarcophaga albiceps *Mg.*, do. (H. M.); 10. S. carnaria *L.*, do. (H. M., Kn.); 11. S. haemorrhoa *Mg.*, do. (H. M.); 12. Scatophaga stercoraria *L.*, do. (Kn.); 13. Sepsis sp., do. (H. M.). (*b*) *Stratiomyidae*: 14. Chrysomyia formosa *Scop.*, skg. (Budd.); 15. Sargus cuprarius *L.*, skg. and po-dvg. (H. M.). (*c*) *Syrphidae*: 16. Ascia podagrica *F.*, skg. and po-dvg. (H. M.); 17. Eristalis sepulcralis *L.*, do. (H. M.); 18. E. tenax *L.*, do. (Kn.); 19. Helophilus floreus *L.*, do. (H. M.); 20. Melithreptus pictus *Mg.*, do. (H. M.); 21. Syritta pipiens *L.*, do. (H. M., Kn.); 22. Syrphus nitidicollis *Mg.*, do. (H. M.); 23. S. ribesii *L.*, do. (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 24. Apis mellifica *L.* ☿, skg. (H. M., Kn.); 25. Halictus sexnotatus *K.* ♀, do. (H. M.); 26. H. tetrazonius *Kl.* ♀, do. (H. M., Kn.); 27. Prosopis sinuata *Schenck* ♀, do. (H. M., Budd.); 28. Sphecodes gibbus *L.* ♀, do. (Budd.).

(*b*) *Chrysididae*: 29. Chrysis ignita *L.*, skg. (H. M.). (*c*) *Evaniidae*: 30. Gasteruption affectator *F.*, skg. (H. M.); 31. G. jaculator *F.*, do. (H. M.). (*d*) *Ichneumonidae*: 32. Ichneumon sp., skg. (H. M.). (*e*) *Scoliidae*: 33. Tiphia minuta *v. d. L.* ♂, skg. (H. M.). (*f*) *Sphegidae*: 34. Crabro chrysostoma *Lep.* ♂, skg. (Budd.); 35. C. clavipes *L.*, do. (H. M.); 36. C. dives *H.-Sch.* ♂, do. (Budd.); 37. C. elongatulus *v. d. L.* ♀, do. (H. M.); 38. C. guttatus *v. d. L.* ♂, do. (Budd.); 39. Oxybelus bellus *Dahlb.*, do. (H.M.); 40. Pseudagenia carbonaria *Scop.* ♂, do. (H.M.); 41. Trypoxylon figulus *L.*, do. (H. M.). (*g*) *Vespidae*: 42. Odynerus parietum *L.* ♂, skg. (H. M., Budd.); 43. Polistes gallica *L.*, do. (Budd.).

Loew observed a Syrphid, Syritta pipiens *L.*, skg., and the honey-bee, Apis mellifica *L.* ☿, skg., in the Berlin Botanic Garden; F. F. Kohl saw the wasp Eumenes pomiformis *F.*, in the Tyrol.

The variety *divaricata* Tenore was seen by Schletterer to be visited at Pola by the bee Prosopis clypearis *Schenck*.

605. R. bracteosa DC. (Knuth, 'Blütenbiol. Beob. a. d. Ins. Capri.')—The flower mechanism and means of attraction in this species agree with those of R. graveolens.

VISITORS.—I observed at Capri only a few Diptera and a species of ant.

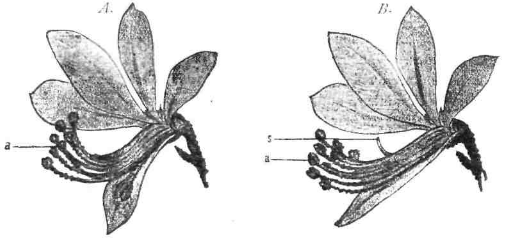


FIG. 74. *Dictamnus albus*, *L.* (From nature.) *A.* Flower in the first (male) condition: the anthers (*a*) occupy the entrance to the flower. *B.* Flower in the second condition: the stigma (*s*) protrudes from among the stamens. (Natural size.)

178. Dictamnus Tourn.

Protandrous hymenopterid flowers.

606. D. albus L. (Delpino, 'Ult. oss.,' p. 145; Hildebrand, Bot. Ztg., Leipzig, xxviii, 1870; Loew, 'Blütenbiol. Floristik,' p. 214; Urban, Jahrb. bot. Gart., Berlin, ii, 1883, pp. 36–404; K. F. Jordan, Ber. D. bot. Ges., Berlin, v, 1887, pp. 327–44; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 203, 225; Knuth, 'Bloemenbiol. Bijdragen.')—The flower mechanism closely resembles that of Aesculus Hippocastanum. As Delpino first demonstrated, the pollen-covered stamens project in the first stage from the flowers (which exhale an odour of citron), while in the second stage the mature stigma protrudes. These parts serve as alighting- and resting-places for insect visitors. During the male stage the stamens lie upon the under-lip of the flower, curving upwards to its entrance, while the style is hidden in the middle

of them. After the pollen has been shed, the filaments straighten, and the style with the mature stigma bends upwards at right angles, so that a female condition ensues. An insect with proboscis of suitable length probing for the nectar secreted in the base of the flower, must therefore introduce its tongue between the petals and the stamens, or stigma, so that when flowers of different ages are visited, cross-pollination necessarily takes place.

VISITORS.—In the Kiel Botanic Garden, I observed the following three bees, all freq., skg.:—1. Megachile willughbiella *K.* ♀ and ♂; 2. Bombus lapidarius *L.* ☿; 3. Apis mellifica *L.* ☿. Of these visitors, however, the honey-bee alone regularly alighted in such a way as to touch the anthers or the stigma, and so constantly effected cross-pollination, the two others often approached laterally, so that they only touched the filaments.

Loew saw two bees in the Berlin Botanic Garden:—1. Apis mellifica *L.* ☿, skg. and po-cltg.; 2. Bombus agrorum *F.* ♀ and ☿, do. On the variety *roseus* he saw two others:—1. Megachile centuncularis *L.* ♀, po-cltg., hovering above the anthers and removing pollen with its ventral brush; 2. M. circumcincta *K.* ♂, skg.

2. TRIBE BORONIEAE.

179. Correa Andr.

Flowers protandrous (Delpino, 'Ult. oss.,' p. 170). Numerous species have been studied in the Berlin Botanic Garden by Urban with regard to pollination (cf. abstract of his paper in Bot. Centralbl., Cassel, xiv, 1883, pp. 200–4).

3. TRIBE TODDALIEAE.

180. Ptelea L.

Flowers greenish, pseudo-hermaphrodite, dioecious, in pseudo-umbellate racemes; with concealed nectar secreted in their bases.

607. P. trifoliata L. (Knuth, 'Bloemenbiol. Bijdragen.')—This North American shrub is occasionally cultivated in our gardens. The whitish-green flowers exhale a strong odour of hyacinths; they secrete a very small quantity of nectar below the ovary, by which it is concealed in the female flower, and in the male flower by the staminal hairs as well. The female flower possesses vestigial stamens, the anthers of which are sterile; the terminal stigma projects 1–2 mm. beyond them. The male flower possesses a moderately large ovary, but this develops no further. The five stamens are closely beset with white hairs of moderate length on the inner side of the lower halves of their filaments. These hairs serve to protect the nectar from rain, and keep off unbidden guests. The anthers dehisce simultaneously, and turn their pollen-covered sides upwards, so that a nectar-seeking insect dusts its head or thorax with a ring of pollen, and when it visits a female flower, this must be applied to the stigma. The male flowers are considerably

larger (diameter 14 mm.) than the female flowers, and have also, it seems to me, a somewhat stronger odour, so that they are first visited by insects.

VISITORS.—In the Kiel Botanic Garden I observed on June 20, 1896, the honey-bee, freq., skg., well dusted with pollen, and a hover-fly, Syritta pipiens *L.*, solitary, po-dvg. and skg.

At the close of his memoir (Jahrb. bot. Gart., Berlin, ii, 1883), Urban gives the following summary of the flower mechanisms observed by him in the Rutaceae.—

I. PLANTS MONOCLINOUS.

A. Flowers protandrous.

1. The filaments bring the anthers one after the other to the place subsequently occupied by the mature stigma, and afterwards return to their original position.

(a) Style (and stigma) undeveloped during the male stage.

(α) **Ruta.** The filaments are at first horizontal, then elongate considerably, apply themselves to the ovary, again move back and become erect. Petals horizontal. Self-pollination usually impossible.

(β) **Coleonema.** The filaments are at first short and erect; they elongate, bend over, and again become straight. Petals meeting together below to form a tube. Automatic self-pollination possible by fall of pollen.

(b) Style developed in the male stage (though sometimes imperfectly), but so placed that self-pollination is impossible.

* Flowers zygomorphous.

(α) **Dictamnus.** The filaments lie upon the under-lip; they become curved, the lower ones first, bend upwards over the middle of the flower, and straighten again after shedding their pollen. The style is at first curved somewhat downwards; after the pollen has been shed, it bends upwards at right angles.

(β) **Calodendron.** The filaments are curved upwards; they elongate, the anterior ones first, and become almost straight before shedding their pollen, finally curving outwards. The style, which is at first curved downwards, straightens after the pollen is shed.

** Flowers actinomorphous. The filaments (successively) elongate considerably after dehiscence.

(α) **Diosma.** The style is at first curved horizontally over the ovary. The petals finally become erect, and the filaments curve outwards between them.

(β) **Adenandra.** As before, but the staminodes, not the petals, incline together at the end. The filaments of the fertile stamens curve outwards but little.

(γ) **Barosma.** The style curves outwards and downwards between the staminodes after the flower opens. The petals remain in a horizontal position, the staminodes are applied to the ovary, and the filaments of fertile stamens resume their original horizontal position after the pollen has been shed.

2. The filaments make only one movement, which they execute simultaneously. In the male stage they are erect, or else somewhat inclined towards one another, *so that the anthers touch; in the female stage the stamens are curved outwards.*

(a) The anthers fall off when the filaments separate. As the stigmatic branches do not diverge till this stage, self-pollination is impossible. **Ravenia.**

(b) The anthers persist after the filaments have separated.

* In the male stage pollen may fall from the anthers upon the still sessile or immature stigma, and thus self-pollination may subsequently result. And later on, owing to the wind or the position of the flowers, pollen from the separate anthers may reach the mature stigma.

(α) **Zieria** and **Eriostemon.** The style continues to grow in the second stage of anthesis.

(β) **Boronia** (ex parte). The stigma matures only at a late stage.

(γ) **Erytrochiton.** The style elongates only at a late stage, but the stigma comes into contact with the anthers before they have separated.

** Neither in the male nor in the female stage can pollen automatically reach the stigma from the anthers, owing to their position, and the adhesive character of the pollen. **Metrodorea.**

3. The filaments execute no movements either before or after the shedding of the pollen.

(a) **Correa.** Self-pollination of the pendulous flowers is ultimately possible after the stigmatic lobes have spread out.

(b) **Agathosma** (ex parte). The style is enclosed by the staminodes in the male stage. In the female stage, the stigmas may still be pollinated, should insect-visits fail, by pollen from the anthers of neighbouring flowers.

B. Flowers homogamous.

1. Automatic self-pollination is impossible—

(a) *in* **Boronia** *(ex parte), owing to the adhesive nature of the pollen;*

(b) in **Triphasia,** because the stigma projects considerably beyond the anthers.

2. Automatic self-pollination is impossible, owing to the position of the filaments, but mutual automatic pollination of neighbouring flowers is favoured by the position and torsion of the anthers. **Agathosma** (ex parte).

3. Automatic self- and cross-pollination are not likely to occur; self-pollination by insect-visits is inevitable. **Crowea.**

4. Automatic self-pollination is possible, but cross-pollination is favoured. **Cusparia, Choisya, Skimmia** (ex parte), **Murraya, Citrus.**

II. Plants Diclinous.

Self-pollination is impossible; cross-pollination furthered. **Ptelea, Skimmia** (ex parte).

XXVII. ORDER *ILICINEAE* DC.

181. Ilex L.

Flowers white, often dioecious, with exposed nectar secreted in their bases.

608. I. Aquifolium L.—This species is described by Vaucher and Darwin as dioecious, but A. Schulz found that cultivated plants bore normal hermaphrodite flowers which set fruits.

MacLeod describes Belgian plants as dioecious (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 246–7). The male flowers possess a vestigial pistil. The anthers dehisce when the flower opens. The female flowers have a much larger ovary, green in colour. In both forms there is but very scanty secretion of nectar.

Visitors.—H. de Vries observed Apis mellifica *L.* ☿, very freq.

XXVIII. ORDER *CELASTRINEAE* R. BR.

Flowers hermaphrodite or unisexual; mostly inconspicuous, with exposed or half-concealed nectar.

182. Euonymus Tourn.

Inconspicuous protandrous flowers, with exposed nectar secreted by a fleshy disk surrounding the style.

609. E. europaeus L. (Delpino, 'Altri appar. dicog. recent. oss.,' p. 52; Herm. Müller, 'Fertilisation,' pp. 162–3; Kirchner, 'Flora v. Stuttgart,' p. 357; Schulz, 'Beiträge,' II, p. 61; Knuth, 'Bloemenbiol. Bijdragen.')—The nectar is spread out in such a thin layer in the green trioecious flowers of this species, and is so readily accessible that it is chiefly sought for by short-tongued insects. The hermaphrodite flowers are protandrous. The four stamens are remote from the stigma, and their filaments are stiff. The anthers dehisce extrorsely, while the stigma is still immature. This unfolds its lobes only several days later, closing them when fertilization has been effected. Automatic self-pollination is therefore entirely excluded (but *vide infra*). When insects visit the flowers cross-pollination almost always takes place. Self-pollination may occur if there have been no insect-visits in the first days of anthesis. Warnstorf describes the pollen-grains as white, ellipsoidal, markedly tuberculated, up to 50 μ long and 25 μ broad. In addition to the hermaphrodite flowers, unisexual ones also occur, in which non-functional vestiges of the opposite sex-organs are present. According to Schulz, they are distributed gynomonoeciously and andromonoeciously, rarely gynodioeciously and androdioeciously.

Visitors.—Schulz noticed Diptera, ichneumon-flies, ants, and beetles, in the South Tyrol. Herm. Müller failed to observe beetles as visitors of the dull yellow flowers of Euonymus, just as he did in the case of the somewhat similarly coloured flowers of Ruta. I, too, have never seen beetles. In North and Central Germany Herm. Müller (H. M.) and myself (Kn.) have observed the following.—

A. Diptera. (*a*) *Bibionidae*: 1. Bibio hortulanus *L.*, skg. (H. M.); 2. Many minute midges (H. M.). (*b*) *Muscidae*: 3. Calliphora erythrocephala *Mg.*, skg. and po-dvg. (H. M.); 4. C. vomitoria *L.*, skg. (H. M., Kn.); 5. Echinomyia fera *L.*, skg. and po-dvg. (Kn.); 6. Lucilia cornicina *F.*, do. (H. M., Kn.); 7. Musca domestica *L.*,

do. (H. M., Kn.); 8. Sarcophaga carnaria *L.*, do. (H. M., Kn.); 9. Scatophaga merdaria *F.*, do. (Kn.); 10. S. stercoraria *L.*, skg. (H. M.). (*c*) *Syrphidae*: 11. Eristalis nemorum *L.*, skg. and po-dvg. (Kn.); 12. E. tenax *L.*, skg. (H. M.); 13. Helophilus floreus *L.*, skg. (H. M.); 14. Syritta pipiens *L.*, do. (H. M.); 15. Syrphus ribesii *L.*, do. (H. M.); 16. S. sp., skg. and po-dvg. (Kn.); 17. Xanthogramma citrofasciata *Deg.*, skg. (H. M.). **B. Hymenoptera.** *Formicidae*: 18. Formica sp., skg. (H. M.).

Schiner saw the hover-fly Criorhina asilica *Fall.*, freq., in Austria.

610. E. latifolius Scop.—

VISITORS.—Loew saw the Muscid Calliphora erythrocephala *Mg.*, skg., in the Berlin Botanic Garden.

611. E. americanus L.—

VISITORS.—Loew noticed the honey-bee, skg., in the Berlin Botanic Garden.

612. E. japonicus Thunb.—This species is a native of Japan.

VISITORS.—In the Tyrol, F. F. Kohl observed the following ruby wasps.—1. Chrysis leachii *Shuck.*; 2. C. viridula *L.*; 3. C. splendidula *Rossi*; 4. C. rutilans *Oliv.*; 5. C. scutellaris *Fabr.*; 6. C. analis *Spin.*; 7. C. distinguenda *Spin.*; 8. C. comparata *Lepel.*; 9. C. inaequalis *Dahlb.*; 10. Stilbum nobile *Sulz.*; 11. Hedychrum nobile *Scop.*; 12. H. rutilans *Dahlb.*; 13. Holopyga rosea *Rossi*; 14. H. chrysonota *Först.*; 15. Ellampus caeruleus *Pall.*: and also the wasps—16. Vespa crabro *L.*; 17. V. germanica *F.*; 18. V. saxonica *Fabr.*; 19. Polistes gallica *L.*; 20. Eumenes pomiformis *F.*; 21. Odynerus floricola *Sauss.*; 22. O. modestus *Sauss.*

Handlirsch, according to Kohl, records the fossorial wasp Gorytes pleuripunctatus *Costa.*

613. E. variegatus.—

VISITORS.—F. F. Kohl records for the Tyrol the wasp—1. Polistes gallica *L.*; and the ruby-wasps—2. Chrysis leachii *Schuck*; 3. C. bidentata *L.*; 4. C. scutellaris *Fabr.*; 4. C. distinguenda *Spin.*; 5. C. inaequalis *Dahlb.*; 6. Holopyga rosea *Rossi.*

183. Celastrus L.

614. C. Orixa Thunb. (= C. japonicus *C. Koch*).—The flowers of this species are green, except the anthers, which are yellow.

VISITORS.—In the Ghent Botanic Garden, Plateau saw po-dvg. Muscidae—Musca domestica *L.*, Calliphora vomitoria *L.*

184. Staphylea L.

Inconspicuous, homogamous flowers associated in racemose inflorescences; nectar half concealed, secreted at the base of the ovary.

615. S. pinnata L. (Kirchner, 'Flora v. Stuttgart,' p. 356; Knuth, 'Bloemenbiol. Bijdragen.')—According to Kirchner, the sepals—which are white, usually tinged with red externally—spread out till in the end they are almost horizontal. The five small white petals are placed vertically in the pendulous flower, and surround the five stamens pretty closely. The cup-shaped green receptacle forms a groove round the base of the ovary, bounded externally by a pentagonal ridge, outside which the stamens are inserted. The approximated stigmas of the two styles are fused together. They are matured simultaneously with the anthers,

and placed almost at the same level, but sometimes they project a little beyond them. In such cases cross-pollination is likely to result from insect-visits. As the stamens closely surround the style, and the anthers dehisce introrsely, the sticky pollen—owing to the pendulous nature of the flower—readily falls upon the stigma.

VISITORS.—In the Kiel Botanic Garden, I observed only the following Diptera, skg. or po-dvg.—(*a*) *Syrphidae*: 1. Eristalis tenax *L.*; 2. Syrphus ribesii *L.*; 3. Melanostoma mellina *L.* (*b*) *Muscidae*: 4. Scatophaga stercoraria *L.*; 5. Lucilia caesar *L.*; 6. Sarcophaga carnaria *L.*

XXIX. ORDER *RHAMNEAE* R. BR.

Inconspicuous protandrous flowers, with exposed nectar. Dioecism frequent, dimorphism occasional.

185. Rhamnus L.

Inconspicuous, frequently dioecious flowers with exposed nectar secreted by the calyx. In some species there are dimorphous flowers (e. g. R. lanceolata, according to Darwin).

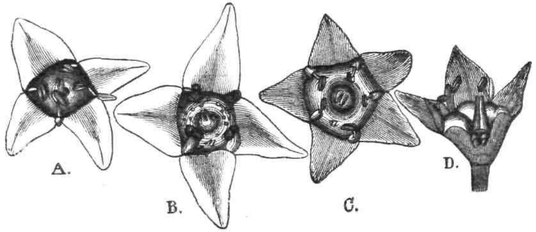


FIG. 75. *Rhamnus pumila, L.* (After Herm. Müller.) *A.* A tetramerous flower with two petals; two anthers have dehisced, and two have not. *B.* A tetramerous flower without any petals; all the anthers have dehisced. *C.* A pentamerous flower with five petals; all the anthers have dehisced. *D.* The same in longitudinal section.

616. R. cathartica L. (MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 248–9; Schulz, 'Beiträge,' II, p. 185; Kirchner, 'Flora v. Stuttgart,' p. 363; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bloemenbiol. Bijdragen.')—Kirchner states that in this species each kind of the greenish, dioecious, fragrant flowers possesses vestiges of the opposite sex-organs. The male flowers are larger than the female: their pistil is either quite rudimentary, and devoid of stigma, or it may be somewhat better developed. The female flowers possess vestigial stamens, and are dimorphous.

According to Warnstorf, shrubs with pseudo-hermaphrodite pollen-flowers are rare at Ruppin and flower more freely than the female stocks. The petals only cover the filaments of the four stiff, erect stamens; the anthers dehisce introrsely. The pollen-grains are white, spheroidal, ellipsoidal, or ovoid, on an average 31 μ long and 25 μ broad.

Visitors.—At Kiel I only saw a hover-fly (Eristalis nemorum *L.*), skg. Hoffer observed Bombus hypnorum *L.* ♀ in Steiermark.

617. **R. pumila** L. (Herm. Müller, 'Alpenblumen,' pp. 169–71.)—The small flowers of this species—which Kerner describes as possessing an odour of honey—are said by Müller to be usually hermaphrodite, while Koch ('Synopsis') describes them as dioecious-polygamous. Cross-pollination is favoured in the hermaphrodite flowers owing to the fact that the stamens and stigmas are on opposite sides of the nectar.

Visitors.—Herm. Müller observed Hymenoptera (Chrysididae, Formicidae), beetles, and Diptera (Muscidae, Empidae, Syrphidae), in the Alps.

618. **R. saxatilis** L.—Kerner describes this species as dioecious, with pseudo-hermaphrodite pollen-flowers and fruiting-flowers.

619. **R. Frangula** L. (=Frangula Alnus *Mill.*). (Herm. Müller, 'Fertilisation,' pp. 163–4, 'Weit. Beob.,' II, p. 212; Kirchner, 'Flora v. Stuttgart,' pp. 363–4; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Schulz, 'Beiträge,' I, p. 31, II, p. 61; Knuth, 'Bloemenbiol. Bijdragen.')—The inconspicuous greenish-white hermaphrodite flowers of this species, according to the investigations of Hermann Müller and A. Schultz, are protandrous to a less (Thuringia) or greater (Westphalia, South Tyrol) degree. The cup-shaped calyx is also a hemispherical nectary. Between the five triangular whitish tips of the sepals, are five small white bifid petals, which almost cover the five inwardly curved introrse stamens. In the base of the calyx lies the short-styled pistil, the bilobed stigma of which is at a lower level than the anthers. At the time when the latter are ripe the stigma is still ill-developed. Insect visitors usually effect cross-pollination while sucking nectar, since they touch the anthers with one side of their body and the stigma with the other. As the flowers, however, are rather inconspicuous, the number of visitors is small, and automatic self-pollination is often effected as a last resort, the withering stamens dropping pollen on the mature stigmas.

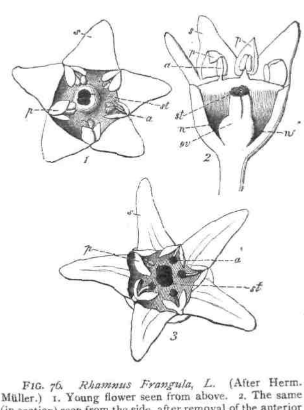


Fig. 76. *Rhamnus Frangula, L.* (After Herm. Müller.) 1. Young flower seen from above. 2. The same (in section) seen from the side, after removal of the anterior half of the calyx. 3. Older flower seen from above. *s*, sepals; *p*, petals; *a*, anthers; *st*, stigma; *ov*, ovary; *n*, nectary.

The account given by A. Schulz differs from that of Müller in some points. He found that in plants growing at Halle and in North Thuringia, the petals are never so deeply cleft as represented by Müller (see Fig. 76). He describes the anthers as being enveloped for a considerable time by the white longitudinally

folded petals, which only become erect and free the anthers at a later stage. Warnstorf gives a similar account of the flower mechanism as observed at Ruppin. The blossoms are homogamous, and when they open the stigmatic papillae are fully developed, and probably ready for pollination. The stamens are at first covered by the small cap-like folded white petals, and subsequently incline inwards towards the stigmas. As the anthers dehisce introrsely, autogamy can take place in the absence of insect-visits. The small smooth pollen-grains are white and irregular, varying from rounded-tetrahedral to nearly ellipsoidal, about 30 μ long and 19 μ broad.

Schulz states that there are two forms of flower, short-styled and long-styled respectively. In the one, as figured by Müller, the style does not attain the level of the anthers, in the other it reaches at least to their bases, and usually to their middle, or even higher. These two forms are local.

Visitors.—Schulz saw at Bozen numerous bees (including Apis), wasps, ichneumon-flies, flies, and beetles; in all about 300 visitors in fourteen days. He noticed similar visitors in Central Germany.

F. F. Kohl saw the wasp Polistes gallica *L.* in the Tyrol.

Hermann Müller observed the following in Westphalia.—

A. Diptera. 1. Culex pipiens *L.* ♂, skg. **B. Hymenoptera.** (*a*) *Apidae*: 2. Apis mellifica *L.* ☿, skg. and po-cltg.; 3. Bombus agrorum *F.* ♀ and ☿, skg.; 4. Macropis labiata *F.* ♂, do. (*b*) *Vespidae*: 5. Eumenes pomiformis *F.*, skg.; 6. Vespa sylvestris *Scop.* ♀, do.

Alfken saw the following at Bremen.—

A. Coleoptera. *Elateridae*: 1. Corymbites sjaelandicus *Müller*; 2. Elater balteatus *L.*; 3. E. pomonae *Steph.*; 4. Sericus brunneus *L.* **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, skg. and po-cltg.; 6. Bombus jonellus *K.* ♀, skg.; 7. B. proteus *Gerst.* ♀; 8. B. terrester *L.* ♀ and ☿.

Schiner noticed a Muscid—Lophosia fasciata *Mg.*—in Austria. MacLeod saw Apis, a humble-bee, an Empis, and a beetle in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 248). And H. de Vries observed the honey-bee in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

620. R. Alaternus L.—

Visitors.—Schmiedeknecht, according to Piccioli, records Andrena schmiedeknechti *Magr.*, for Florence.

186. Paliurus Tourn.

621. P. aculeatus Lam. (=P. australis *Gaertn.*).—According to Delpino ('Altri appar. dicog. recent. oss.,' pp. 51–2), this species is markedly protandrous. The stamens are at first erect or slightly bent inwards, shed their pollen, and then curve outwards, while the stigmas mature.

Visitors.—Schiner saw a hover-fly—Spilomyia speciosa *Rossi*—in Austria.

Schletterer observed the following **Hymenoptera** at Pola.—

(*a*) *Apidae*: 1. Anthidium diadema *Ltr.*; 2. A. variegatum *F.*; 3. Andrena austriaca *Pz.*; 4. A. colletiformis *Mor.*; 5. A. flavipes *Pz.*; 6. A. nana *K.*; 7. Ceratina cucurbitina *Rossi*; 8. Colletes lacunatus *Dours.*; 9. Epeolus scalaris *Ill.*; 10. Eriades campanularum *K.*; 11. Halictus calceatus *Scop.*; 12. H. interruptus *Pz.*;

13. H. leucozonius *Schr.* ♀; 14. H. tetrazonius *Klg.*; 15. Nomia diversipes *Ltr.*; 16. Osmia cephalotes *Mor.*; 17. Prosopis clypearis *Schenck*; 18. P. hyalinata *Sm.*, var. subquadrata *Först.*; 19. P. pictipes *Nyl.*; 20. P. variegatus *F.*; 21. Sphecodes gibbus *L.*; 22. S. subquadratus *Sm.* (*b*) *Braconidae*: 23. Bracon castrator *F.*; 24. B. nominator *F.*; 25. B. terrefactor *Vill.* ♀; 26. B. urinator *F.*; 27. B. xanthogaster *Krchb.* one ♀, and one ♂; 28. Isomecus schlettereri *Krchb.*; 29. Microgaster subcompletus *Nees*; 30. M. tibialis *Nees.* (*c*) *Chalcididae*: 31. Brachymeria minuta *L.*; 32. Leucaspis dorsigera *F.*, rare; 33. L. intermedia *Ill.*, rare. (*d*) *Chrysididae*: 34. Chrysis igniventris *Ab.*; 35. C. chevrieri *Mocs.*; 36. C. inaequalis *Dahlb.*; 37. C. indigotea *Duf. et Pér.*; 38. C. jucunda *Mocs.*; 39. C. pustulosa *Ab.*; 40. C. refulgens *Spin.*; 41. C. splendidula *Rossi*; 42. C. succincta *L.*; 43. Ellampus spina *Lep.*; 44. Holopyga amoenula *Dahlb.*; 45. H. chrysonota *Först.*; 46. H. curvata *Först.*; 47. H. gloriosa *F.* (*e*) *Evaniidae*: 48. Gasteruption affectator *L.*; 49. G. granulithorax *Tourn.*; 50. G. kriechbaumeri *Schlett.*; 51. G. opacum *Tourn.*; 52. G. pedemontanum *Tourn.*; 53. G. rubricans *Guér.*; 54. G. terrestre *Tourn.*; 55. G. tibiale *Tourn.*; 56. G. tournieri *Schlett.* (*f*) *Ichneumonidae*: 57. Amblyteles armatorius *Först.*; 58. Casinaria tenuiventris *Gr.*; 59. Crypturus argiolus *Rossi*; 60. Cryptus bucculentus *Tschek.*; 61. C. viduatorius *F.*; 62. Exephanes hilaris *Wesm.*; 63. Exetastes guttatorius *Gr.*, var. procera *Krchb.*; 64. Glypta ceratites *Gr.*; 65. Hoplismenus armatorius *Pz.*; 66. Ichneumon balteatus *Wesm.*; 67. I. consimilis *Wesm.*; 68. I. monostagon *Gr.*; 69. I. pisorius (L.) *Gr.*; 70. I. sarcitorius *L.*; 71. Limneria chrysosticta *Gr.*; 72. Linoceras macrobatus *Gr.*, var. geniculata *Krchb.*; 73. Lissonota folii *Ths.*; 74. L. verberans *Gr.*, var. procera *Krchb.*; 75. Mesostenus grammicus *Gr.*; 76. M. grammicus *Gr.* var. nigroscutellata *Krchb.*; 77. Metopius dentatus *F.*; 78. M. micratorius *F.*; 79. Onorga mutabilis *Hgr.*; 80. Ophion (Eremotylus) undulatus *Gr.*; 81. Phygadeuon (Campoplex) nitens *Gr.*; 82. Pimpla illecebrator *Pz.*; 83. P. instigator *Gr.*; 84. P. turionellae *L.*; 85. P. vesicaria *Ratzeb.*; 86. Pristomerus vulnerator *Pz.*; 87. Sagaritis annulata *Gr.*; 88. S. annulata *Gr.*, var. fuscicarpus *Krchb.*; 89. Spilocryptus claviventris *Krchb.*; 90. Trachynotus foliator *F.*, extremely freq.; 91. Trichomma enecator *Rossi*; 92. Trychosis plebeius *Tschek.*, var. nigritarsis *Krchb.* (*g*) *Pompilidae*: 93. Agenia variegata *L.*; 94. Ceropales variegatus *F.*; 95. Pompilus aterrimus *Rossi*; 96. P. cellularis *Dahlb.*; 97. P. cingulatus *Rossi*; 98. P. latebricola *Kohl.*; 99. P. nigerrimus *Scop.*; 100. P. quadripunctatus *F.*; 101. P. ursus *F.*; 102. P. vagans *Klug.*; 103. P. viaticus *L.*; 104. Pseudagenia albifrons *Dalm.*; 105. P. carbonaria *Scop.*; 106. Salius affinis *v. d. L.*; 107. S. elegans *Spin.*; 108. S. fuscus *F.* (*h*) *Scoliidae*: 109. Myzine tripunctata *Rossi*; 110. Tiphia femorata *F.*, rare; 111. T. morio *F.* (*i*) *Sphegidae*: 112. Astata boöps *Schr.*; 113. A. minor *Kohl.*; 114. Cerceris arenaria *L.*; 115. C. bupresticida *Duf.*; 116. C. conigera *Dahlb.*; 117. C. emarginata *Pz.*; 118. C. quadricincta *Vill.*; 119. C. quadrimaculata *Duf.*; 120. C. quinquefasciata *Rossi*; 121. C. specularis *Costa*; 122. Crabro clypeatus *Schreb.*; 123. C. meridionalis *Costa*; 124. C. vagus *L.*, freq.; 125. Gorytes consanguineus *Handl.*; 126. G. pleuripunctatus *Costa*; 127. G. procrustes *Handl.*; 128. G. quinquecinctus *F.*; 129. Larra anathema *Rossi*, one ♂; 130. Nysson scalaris *Ill.*; 131. Pemphredon shuckardi *A. Mor.*, one ♀; 132. P. unicolor *F.*; 133. Psen pallidipes *Pz.*, one ♂; 134. Sceliphron destillatorium *Ill.*, very freq.; 135. S. omissum *Kohl.*, rather rare; 136. S. spirifex *L.*, several ♂; 137. Tachysphex nitidus *Spin.*; 138. T. rufipes *Aich.* (*k*) *Tenthredinidae*: 139. Allantus viduus *Rossi*; 140. Arge cyaneocrocea *Först.*; 141. Athalia rosae *L.*, var. cordata *Lep.*; 142. Cephus (Philoecus) pareyssei *Spin.*; 143. Emphytus balteatus *Klg.*; 144. Macrophya diversipes *Schr.*; 145. M. neglecta *Klg.*; 146. M. rustica *L.*; 147. Tenthredopsis austriaca *Knw.*; 148. T. dorsalis *Lep.*; 149. T. raddatzi *Knw.*, var. vittata *Knw.*; 150. T. thomsoni *Knw.*, var. femoralis *Steph.*; 151. T. thomsoni *Knw.*, var. nigripes *Knw.* (*l*) *Vespidae*: 152. Eumenes mediterranea *Krchb.*; 153. E. pomiformis *F.*; 154. Odynerus alpestris *Sauss.*; 155. O. bidentatus *Lep.*; 156. O. dantici *Rossi*; 157. O. floricola *Sauss.*; 158. O. levipes *Shuck.*; 159. O. modestus *Sauss.*; 160. O. parietum *L.*; 161. Polistes gallica *L.*

XXX. ORDER *AMPELIDEAE* H. B. K.

Small, green, but fragrant flowers, homogamous or protandrous.

187. Ampelopsis Michx.

Protandrous flowers with concealed nectar, secreted at the base of the ovary.

622. A. quinquefolia Michx.—Kirchner ('Flora v. Stuttgart,' p. 362) states that the nectar is secreted in minute drops under the base of the ovary. After the flower has opened the green petals become completely reflexed, while the five stamens become erect, and their anthers dehisce introrsely. These then turn their pollen-covered surfaces upwards, and at this stage project about 1 mm. beyond the still immature stigma. The stigma does not become receptive until the petals and stamens have dropped off.

VISITORS.—Kirchner observed the honey-bee. I myself observed Lucilia caesar *L.* at work on the anthers. According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 206), the flowers are much visited by bees, attracted by an odour which is imperceptible to us. Plateau also noticed Apis in Belgium.

188. Vitis L.

Flowers homogamous, with exposed nectaries. Perhaps there is also wind-pollination. Focke (Abh. natw. Ver., Bremen, xiv, *1897*, p. *302*) states that some of the species are androdioecious. According to Beach (Bot. Gaz., Chicago (Ill.), xvii, *1892*), self-pollination frequently takes place in the still unopened flowers.

623. V. vinifera L. (Kirchner, 'Flora v. Stuttgart,' p. 361; Rathay, see Bibliography; Kronfeld, Ber. D. bot. Ges., Berlin, vii, 1889, p. 42; Knuth, 'Bloemenbiol. Bijdragen.')—The inconspicuous, small, yellowish-green flowers of this species attract insects by their delightful odour. At the base of the ovary, between the filaments, are five (more rarely six) yellow, fleshy nectaries. The flowers, as is well known, open by the five (rarely six) green petals becoming detached at the base, and falling off in the form of a cap. The five (or six) stamens spread out, and the upper sides of the anthers become covered with pollen. The stigma matures simultaneously, but, according to Kirchner, remains receptive after the anthers have withered. As it is at a lower level than the anthers, automatic self-pollination is possible, and Kirchner says that it is effective.

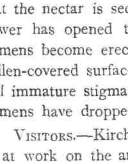


FIG. 77. *Vitis vinifera, L.* (From nature.) *n*, nectary.

Rathay asserts that the five nectaries are non-functional, but according to Delpino, they secrete freely. Portele says that the stigmatic secretion is strongly saccharine, but Rathay was only able to find traces of grape-sugar. The latter authority considers the vine to be anemophilous—because he proved that the wind can carry away individual pollen-grains from the dehisced anthers ('Geschlechtsverhältnisse der Reben,' I, pp. 31 et seq.)—and entomophilous as well—for he observed

(op. cit., II, pp. 16 et seq.) twenty-seven different insect visitors (*vide infra*). These appeared on specially warm days, and a ♀, belonging to one of the four species of Halictus, was loaded with large balls of pollen derived entirely from grape-flowers. Kirchner ('Über einige irrtümlich für windblütig gehaltene Pflanzen,' Jahreshefte Ver. Natk., Stuttgart, xlix, 1893, pp. 98 et seq.) points out that the possibility of transport of pollen-grains by the wind does not prove that anemophily takes place to any considerable extent, for with the wind blowing steadily in one direction, a pollen-grain took 200 hours to reach a stigma tolerably near. And he asserts that this is in direct opposition to all our experimental knowledge of undoubtedly wind-pollinated plants, while the whole structure of the vine-flower as regards stigma and pollen is equally contradictory of anemophily. At the time when the stigma is receptive, it is covered with short papillae, and secretes an abundant supply of glistening stigmatic fluid, which is well adapted to hold any pollen-grains that reach it, but not at all fitted for catching grains, its surface being much too small for such a purpose. Besides, not a single undoubtedly wind-pollinated flower is known with a stigma secreting a sticky fluid. Kirchner goes on to say that the pollen is but slightly coherent, the individual grains possessing a smooth extine, not beset with oil droplets. It is produced in remarkably small quantity for a supposed anemophilous plant, and is by no means readily blown away from the dehisced anthers. But were the vine-flower wind-pollinated, the opposite might be expected to a marked extent, since the filaments are rigid, and the anthers firmly and immovably attached to them. The inconspicuousness of the small flowers is counterbalanced by their extreme fragrance, which would undoubtedly suffice to attract numerous insects, if the booty offered were of proportionate amount. But the quantity of pollen is small, and, according to all available accounts, nectar never appears to be secreted—at least in Central Europe—a fact that may well restrain the clever bees from visiting the flowers at a time when so many other copious sources of nectar are available. This deficiency, however, the last piece of evidence supporting the theory of anemophily, is not absolute, for when an observer of the rank of Delpino asserts that nectar is abundantly secreted by the five glands at the base of the ovary, we are obliged to conclude that in warmer regions than ours the vine behaves differently, and that its flowers do actually produce nectar. According to Rathay, the glands in question are the odour-producing organs. Kirchner is confirmed by Delpino's account in a view long entertained by him, i. e. that in our climate the vine has lost the power of producing nectar which it formerly possessed. It is really a native of warmer regions, but has been cultivated for the sake of its fruit to the utmost possible northern limit.

The fertilization of the hermaphrodite flowers obviously results from automatic self-pollination, for it is specially favoured by warm still weather. Besides this autogamy, there is no doubt that geitonogamy frequently takes place (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 326), the stigmas receiving pollen from neighbouring flowers. The position and direction of the stigmas do not alter, but the filaments elongate, and curve sufficiently to enable the transfer of pollen to adjacent flowers. Cross-pollination is chiefly effected by insects, as already stated, but it is quite possible that the wind sometimes carries the loose pollen from one flower to others which are not far distant.

The flowers of the vines I examined at Kiel were all thickly covered with yellow pollen, from which circumstance it appeared to me to be likely that autogamy and geitonogamy may occasionally be effected by the wind, while xenogamy may be brought about by insects.

Rathay states that cultivated vines may be gynodioecious or andromonoecious, and wild ones dioecious with pseudo-hermaphrodite pollen and fruiting flowers. According to Focke (Abh. natw. Ver., Bremen, xiv, 1897, p. 302) the hermaphrodite form of Vitis vinifera *L.* is perfectly fertile in itself; in the case of V. cordifolia *Mchx.* the pollen of the male form is necessary for the production of good fruit. This latter species is therefore almost dioecious.

VISITORS.—At Kiel I observed the honey-bee and B. terrester *L.*, po-cltg., as they flew from flower to flower. The humble-bees in particular were so active that they constantly came back again, though repeatedly driven away by the owner of the vines, who feared that the flowers might be injured. Kronfeld (Ber. D. bot. Ges., vii, 1889) also saw numerous honey-bees in a garden at Ober-St.-Veit.

Rathay has observed the largest number of visitors, as follows ('Die Geschlechtsverhältnisse der Reben,' Part 2, 1889, pp. 17–23).—

A. Coleoptera. 1. Adrastus humilis *Er.*; 2. Agriotes ustulatus *Schaller*; 3. Anaglyptus mysticus *L.*; 4. Anaspis pulicaria *Costa.*; 5. Clytra musciformis *Göze*; 6. Clytus figuratus *Scop.*; 7. C. ornatus *Herbst.*; 8. Danacea nigritarsis *Küst.*; 9. Dasytes plumbeus *Müll.*; 10. Adoxus obscurus *L.*, var. vitis *Fabr.*; 11. Limonius lythrodes *Germ.*; 12. Malachius elegans *Oliv.*; 13. M. geniculatus *Germ.*; 14. Meligethes brassicae *Scop.*; 15. Nacerdes austriacus *Ggb.*; 16. Notoxys cornutus *Fabr.*; 17. N. monoceros *L.*; 18. Oxythyrea funesta *Poda.*; 19. Phyllopertha horticola *L.*; 20. Spermophagus cardui *Stev.*; 21. Epilachna globosa *Schneid.* **B. Diptera.** 22. Sciara sp. **C. Hymenoptera.** 23. Andrena sp. ♀; 24. Apis mellifica *L.*; 25. Halictus albipes *F.*, var. affinis *Schenck*; 26. H. morio *F.*; 27. H. villosulus *K.* **D. Hemiptera.** 28. Two undetermined specimens.

Rathay also gives (op. cit.) the following visitors for different varieties of the vine.—

A. Coleoptera. 1. Adrastus humilis *Er.*, 1 on 'Zimmet-traube'; 2. Anaspis pulicaria *Costa.*, 2 on 'Zimmet-traube'; 3. Clytra musciformis *Goeze*, 1 on 'Zimmet-traube'; 4. Clytus figuratus *Scop.*, 6 on 'Zimmet-traube'; 5. Danacea nigritarsis *Küst.*, 2 on 'Zimmet-traube'; 6. Dasytes plumbeus *Müll.*, 1 on 'Zimmet-traube,' 1 on V. riparia; 7. Adoxus obscurus *L.*, var. vitis *Fabr.*, 1 on 'Zimmet-traube'; 8. Limonius lythrodes *Germ.*, 1 on 'Zimmet-traube'; 9. Malachius geniculatus *Germ.*, 2 on 'Zimmet-traube,' 3 on V. riparia; 10. Meligethes brassicae *Scop.*, 3 on blue Kardaka (V. vinifera), 10 on 'Zimmet-traube' (V. vinif.); 11. Nacerdes austriaca *Ggb.*, 5 ♀ and 2 ♂ on 'Zimmet-traube'; 12. Oedemera lurida *Marsh.*, 1 on V. riparia; 13. Oxythyrea funesta *Poda.*, 1 on 'Zimmet-traube'; 14. Phyllopertha horticola *L.*, 2 on 'Zimmet-traube'; 15. Spermophagus cardui *Stev.*, 3 on V. riparia, 2 on 'Zimmet-traube'; 16. Subcoccinella 24-punctata *L.*, 1 on 'Zimmet-traube.' **B. Diptera.** 17. Sciara sp., 2 on 'Zimmet-traube'; 18. Syritta pipiens *L.*, 1 on V. riparia. **C. Hymenoptera.** 19. Halictus albipes *F.*, var. affinis *Schenck*, 2 on 'Zimmet-traube'; 20. H. morio *F.*, 1 on 'Zimmet-traube.'

Supplementary list.—

A. Coleoptera. 1. Coccinella bipunctata *L.*, 1 on V. riparia; 2. Agriotes ustulatus *Schall.*, 1 on V. vinifera; 3. Anaglyptus mysticus *L.*, 1 on V. viniferas 4. Anaspis melanostoma *Cost.*, 1 on V. rupestris candicans; 5. Ceutorrhynchus suturalis *Fabr.*, 1 on V. riparia; 6. Cis hispidus *Payk.*, 1 on V. riparia; 7. Clytus

figuratus *Scop.*, 1 on V. vinifera, 1 on Taylor-seedling; 8. C. ornatus *Hbst.*, 2 on V. vinifera; 9. Coccinella septem-punctata *L.*, 1 on riparia; 10. Dasytes plumbeus *Müll.*, 1 on V. riparia, 1 on V. cordifolia rupestris; 11. Clytra affinis *Hellw.*, 1 on Clinton; 12. Limonius bructeri *Panz.*, 1 on V. riparia; 13. Malachius aeneus *L.*, 2 on V. riparia; 14. M. elegans *Oliv.*, 3 on V. riparia, 2 on V. rupestris, 1 on V. vinifera, 1 on Othello (V. riparia vinifera, American variety), 1 on Taylor-seedling (V. riparia labrusca), 2 on Clinton (V. riparia labrusca); 15. Meligethes brassicae *Scop.*, 3 on V. riparia, 1 on V. arizonica; 16. M. pedicularis *Gyll.*, 1 on V. riparia; 17. Nacerdes austriacus *Gyll.*, 4 on Clinton, 3 on Solonis (V. riparia, V. rupestris, V. candicans); 18. Notoxys cornutus *Fabr.*, 6 on V. vinifera; 19. N. monoceros *L.*, 4 on V. vinifera; 20. Oedemera lurida *Marsh.*, 1 on V. riparia; 21. Omophlus longicornis *Bert.*, 1 on V. riparia; 22. Oxythyrea funesta *Poda.*, 1 on V. riparia; 23. Spermophagus cardui *Stev.*, 1 on V. riparia, 1 on V. vinifera, 1 on V. Solonis. **B. Diptera.** 24. An Anthomyid, 1 on V. riparia; 25. Pipizella virens *Fabr.*, 1 on V. riparia, 1 on V. Solonis; 26. Syritta pipiens *L.*, 4 on V. riparia, 4 on V. rupestris. **C. Hymenoptera.** 27. Andrena sp.? ♀, 1 on V. vinifera; 28. Apis mellifica *L.*, 5 on V. riparia, 8 on V. vinifera; 29. Halictus morio *F.* ♀, 1 on Clinton; 30. H. sp. ♀, 1 on Clinton; 31. H. villosulus *Kirb.* ♀. **D. Hemiptera.** 32. Two undetermined specimens on V. vinifera.

XXXI. ORDER *SAPINDACEAE*.

1. Sub-order Sapindeae.

The large flowers of the species cultivated in Europe are rendered very conspicuous by their aggregation into large candelabra-like inflorescences of considerable size. The flowers belong to class **B**, for nectar is secreted and concealed in their bases.

189. Aesculus L.

624. A. Hippocastanum L. (Sprengel, 'Entd. Geh.,' pp. 209–14; Herm. Müller, 'Fertilisation,' pp. 164–6; Kirchner, 'Flora v. Stuttgart,' p. 349; Knuth, 'Grundriss d. Blütenbiol.,' pp. 35–6, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 50, 'Bloemenbiol. Bijdragen'; Hildebrand, 'D. Geschlechts-Vert. b. d. Pfl.,' pp. 11, 26; Beyer, 'D. spont. Bewegung. d. Staubgefässe u. Stempel'; Martelli, Nuovo Giorn. bot. ital., Firenze, xx, 1888, pp. 401–4; Ogle, Pop. Sci. Rev., London, ix, 1870, p. 54; K. Fr. Jordan, Ber. D. bot. Ges., Berlin, v, 1887; Focke, Verh. bot. Ver., Berlin, xxxi, 1889, pp. 108–12.)—The species is coenomonoecious. It is remarkable that Sprengel describes the hermaphrodite white flowers as protandrous, though they are really protogynous, as first correctly pointed out by Hildebrand. The two upper petals are the largest, while the lowest one is the smallest. They possess nectar-guides which are at first yellow, afterwards assuming a carmine hue. Focke says that this coloration renders the inflorescences more conspicuous as a whole. Nectar is secreted in the bottom of the calyx, between the claws of the upper petals and stamens. It is protected by the horizontal position of the flowers, the folding of the petals, and woolly hairs on the petals and stamens. Hermaphrodite, male, and female flowers are associated in the same inflorescence. In hermaphrodite flowers the stamens are curved downwards so long as the anthers are immature, while the style projects horizontally from the flower. In the second stage, the stamens with their ripe anthers curve upwards, but after shedding their pollen return to their first position. In harmony with the protogyny of the hermaphrodite flowers is the

fact that the first flowers of an inflorescence to open are all purely male (with vestigial pistils), while it usually happens that in the lower part of the inflorescence, some flowers are actually female, since their anthers fall off without dehiscing, although the pollen-sacs are full of pollen-grains (Müller). Martelli states (op. cit.) that the lowest flowers are the only fertile ones, and that not more than two to four of them produce seeds, these being the fourth (rarely the third) to the seventh in regular succession, counting from the base of the cyme.

Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896, pp. 1–12) gives a similar account of the distribution of the sexes. The lower flowers of the panicle are male, and are the first to open; towards the middle isolated pseudo-hermaphrodite pollen-flowers, with no style and a sessile stigma are often to be found. The upper flowers are hermaphrodite and protogynous, with projecting styles; their ovaries are beset with stalked red glands of large size. The smooth pollen-grains are vermilion in colour and ellipsoidal, with several longitudinal furrows; size about 20 μ broad and 37–40 μ long.

The dimensions of the flowers correspond with those of the chief visitors, humble-bees, which when alighting at once settle in the most convenient position

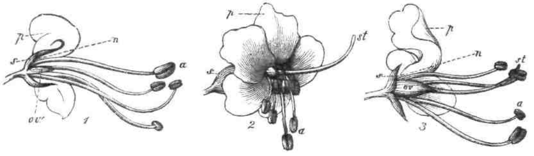


FIG. 78. *Aesculus Hippocastanum*, *L.* (After Herm. Müller.) 1. Male flower in section. 2. Hermaphrodite flower in the first (male) condition, seen obliquely from the front. 3. The same in the second (female) condition, in section. *a*, anthers; *n*, nectary; *ov*, ovary; *ov*[1], vestigial ovary; *p*, petals; *s*, sepals; *st.* stigma.

for sucking, and in so doing touch either the stigma or the anthers with the underside of the abdomen, so that cross-pollination is always effected. The other bees observed by Herm. Müller (Apis, Eucera, Osmia rufa *L.*, Halictus rubicundus *Chr.*, Andrena) do not correspond with the flowers in dimension.

VISITORS.—*The height of the trees makes it very difficult to observe visitors,* but I was able to carefully note the following actively engaged on the flowers.—

A. Diptera. (*a*) *Muscidae*: 1. Musca domestica *L.*, skg. from the side without touching stigma or stamens; 2. Scatophaga merdaria *L.*, do.; 3. S. stercoraria *L.*, do. (*b*) *Syrphidae*: 4. Syritta pipiens *L.*, skg. from the side as before, also po-dvg., but not touching the stigma; 5. Syrphus balteatus *Deg.*, as Musca. **B. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.* ☿, skg. while hanging on the filaments from below, and therefore touching neither stigma nor anthers; sometimes also po-cltg.; 7. Bombus lapidarius *L.* ♀, skg. legitimately and effecting pollination; 8. B. terrester *L.* ♀ and ☿, do.

Loew saw the honey-bee, skg. and po-cltg., in the Berlin Botanic Garden.

Alfken and Hopper (H.) noticed the following *Apidae* at Bremen:—1. Apis mellifica *L.* ☿; 2. Bombus terrester *L.* ♀; 3. Podalirius retusus *L.*, var. obscurus *Friese* ♀ (H.). All freq., skg.; 1 and 2 also po-cltg.

625. A. carnea Willd.—In this species again, according to Martelli (op. cit.), the flowers are not all fertile. Such are to be found, singly or in pairs, among sterile ones on the same inflorescence. And as before, only the lower part of the whole inflorescence is fertile. Sterile flowers occur in A. flava, but the great majority are fertile. There is no difference between the parts of the entire inflorescence, or its component branches. Focke (Abh. natw. Ver., Bremen, xiv, 1897, p. 302) states that the species of Aesculus (Pavia), cultivated in Germany, are andromonoecious, like the horse-chestnut. For the production of fruit, cross-pollination (by humble-bees) is generally necessary.

626. A. Pavia L. (= Pavia rubra *Link*). (Warnstorf, Schr. natw. Ver., Wernigerode, xi, 1896.)—In this species the lower flowers of the branches of the panicle are hermaphrodite and fertile, and the next above them pseudo-hermaphrodite; or all the flowers may be pseudo-hermaphrodite. The two posterior and larger petals possess a yellow nectar-guide, which later on assumes an intensely red colour. The stamens are about as long as these petals. The pollen-grains are vermilion in colour, ellipsoidal, with longitudinal furrows; on an average they are 25–30 μ broad and 42 μ long.

VISITORS.—Alfken observed the following *Apidae* at Bremen.—1. Apis mellifica *L.* ☿; 2. Bombus hortorum *L.* ♀; 3. B. lucorum *L.* ♀; 4. B. muscorum *F.* ♀; 5. B. ruderatus *F.* ♀; 6. Psithyrus barbutellus *K.* ♀, skg.; 7. P. vestalis *Fourcr.* 1–5 skg. and po-cltg.

627. A. rubicunda Lodd. ('D. Geschlechts-Vert. b. d. Pfl.,' pp. 26–7.)—The species is andromonoecious with protogynous hermaphrodite flowers. While Hildebrand found all the earliest flowers of the panicle to be purely male, Kirchner (' Neue Beob. ü. d. Bestäubungseinricht. einheim. Pfl.,' p. 31) says they are hermaphrodite, occurring chiefly in the lower part of the inflorescence, where male flowers greatly predominate as a rule.

628. A. flava Ait.—Martelli found most of the flowers to be fertile in this species (cf. A. carnea). Focke saw many blossoms that had been perforated by Bombus terrester.

629. A. macrostachya Michx. (Kirchner, 'Beiträge,' p. 30; Knuth, 'Bloemenbiol. Bijdragen.')—The species is andromonoecious, with protandrous hermaphrodite blossoms, which are perhaps moth flowers. They are horizontal, white in colour except for the red anthers, and exhale an odour of lilies. Nectar is secreted outside the bases of the upper stamens. The tubular gamosepalous calyx is 7–8 mm. long. The petals are slender, with long claws, and at first 12 mm. in length. To begin with, the stamens are of the same length, but afterwards project 20–25 mm. out of the corolla, when their anthers dehisce successively. After these have shed their pollen, withered, and curved downwards, the stigma becomes fully mature, and at this stage the style is over 30 mm. long. In male flowers the pistil is vestigial.

VISITORS.—Kirchner observed the honey-bee, but supposes from the structure, colour, and odour of the flowers, that nocturnal hawk-moths are the real pollinators. In the Kiel Botanic Garden I too saw the honey-bee, skg., and also Bombus hortorum *L.* ☿. These two insects did not fly, but crept from flower to flower.

190. Melianthus L.

630. M. major L.—Francke describes the flowers of this species as protandrous ('Beiträge z. Kennt. d. Bestäubungseinricht. d. Pfl.').

2. SUB-ORDER ACERINEAE.

This suborder is represented in Europe only by the genus.

191. Acer L.

Several or many of the small greenish-yellow flowers are crowded together into inflorescences, and thus rendered conspicuous. Some species blossom before the leaves unfold, by which the same end is attained to a marked degree. Nectar is secreted by a thick fleshy central disk, and is fully exposed. The flowers therefore belong to class **E**. They are usually monoecious, rarely dioecious.

631. A. platanoides L. (Herm. Müller, 'Weit. Beob.,' II, pp. 212–13; Kirchner, 'Flora v. Stuttgart,' p. 351; Wittrock, Bot. Centralbl., Cassel, xxv, 1886, p. 55; K. Fr. Jordan, Ber. D. bot. Ges., Berlin, v, 1887; Knuth, 'Grundriss d. Blütenbiol.';

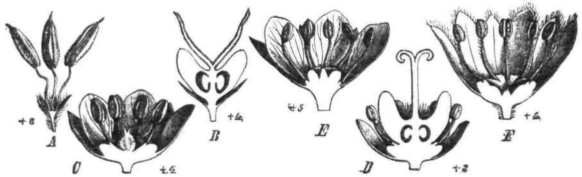


FIG. 79. *Acer, L.* (After F. Pax.) Flowers of various species in longitudinal section. *A* ♂, *B* ♀, of A. Negundo. *C* and *D*, do. of A. Pseudo-Platanus. *E*. A. Hookeri. *F*. A. campestre.

Warnstorf, Schr. natw. Ver., Wernigerode, xi, 1896.)—The flowers appear before the leaves in this species. The stamens, usually eight in number, arise from pits in the fleshy disk, which is covered with minute drops of nectar lying quite exposed. Wittrock states that the inflorescences are of five kinds, according to the distribution of the male and female flowers on the inflorescence. These are composed, respectively, of:—1. female flowers exclusively; 2. the flowers first developed are female, and the later ones male; 3. the earliest flowers are male (at the apex), then follow male and female, and the last to open are mostly male; 4. male flowers are first developed, and then female; 5. all the flowers are male. Only one of these varieties of inflorescence is found on most trees, but two, or even three of them, may be associated on the same tree in exceptional cases. The commonest kind is 2 (about 40 % in the trees examined by Wittrock), then follow in order 4 (22 %), 5 (12 %), 3 (4 %), 1 (not quite 1 %).

The female flowers possess stamens that appear normal, as do the numerous pollen-grains contained in the anthers, which, however, never dehisce. The filaments

are considerably shorter than those of male flowers, in which they are so long that the anthers about reach the tips of the petals: they surround a vestigial pistil. After fertilization the female flowers close, the sepals and petals becoming erect. Warnstorf describes the pollen-grains as pale yellow in colour, ellipsoidal, with three longitudinal grooves, very delicately striated, about 50 μ long and 20 μ broad.

VISITORS.—Herm. Müller observed the honey-bee.

632. A. campestre L.—The greenish flowers of this species open at the same time that the leaves unfold, they are much less conspicuous than those of A. platanoides, with which, according to Wittrock, they entirely correspond as regards mechanism and distribution of sexes.

VISITORS.—Alfken observed 3 *Apidae* at Bremen:—1. Andrena nigro-aenea *K.* ♀; 2. A. trimmerana *K.* ♀; 3. Apis mellifica *L.* ☿.

H. de Vries saw Apis mellifica *L.* ☿, freq., in the Netherlands (Ned. Kruidk. Ach., Nijmegen, 2. ser., 2. deel, 1875).

633. A. Pseudo-Platanus L.—This species does not blossom till the leaves have unfolded. Wittrock states that the flowers agree essentially with those of A. platanoides, except that purely male or purely female inflorescences have not so far been observed. According to Jordan, there is a nectar-cover, in the form of white hairs at the bases of the stamens.

Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896) gives the following account.—Inflorescence a racemose panicle; flowers markedly protandrous. Lower floral axes branched, with male and pseudo-hermaphrodite fruiting-flowers; the middle ones being either almost purely female. and the upper ones mixed male and female, or the former mixed female and male, and the latter purely female. The filaments of the male flowers project far beyond the petals, while those of the female flowers are very short, and do not exceed the petals in length.

VISITORS.—Herm. Müller observed the following.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, skg.; 2. E. tenax *L.*, do.; 3. Syrphus ribesii *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 4. Andrena albicans *Müll.* ♀, skg.; 5. Anthophora aestivalis *Pz.* ♀, do.; 6. Bombus hortorum *L.* ♀, do.; 7. B. lapidarius *L.* ♀, do.; 8. B. rajellus *K.* ♀, do.; 9. B. terrester *L.* ♀, do.; 10. Melecta luctuosa *Scop.* ♀, do.; 11. Osmia emarginata *Lep.* ♀, do.; 12. Psithyrus barbutellus *K.* ♀, do.

Loew noticed the following in the Berlin Botanic Garden.—

A. Diptera. *Bibionidae*: 1. Bibio hortulanus *L.* ♀, skg. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.*, skg.

Friese saw the following *Apidae* in Hungary.—1. Andrena bucephala *Stph.*, freq.; 2. A. gwynana *K.*, 2nd generation; 3. A. mitis *Pér.*; 4. A. rufula *Pér.*; 5. A. trimmerana *K.*; 6. Nomada alternata *K.*; 7. N. bifida *Ths.*; 8. N. ruficornis *L.*; 9. N. succincta *Pz.*

634. A. dasycarpum Ehrh.—In this North American species, occasionally cultivated in Europe, the flowers are arranged in dense clustered inflorescences, and open long before the leaves unfold. Kirchner ('Flora v. Stuttgart,' p. 352) says that the diameter of the male flowers is only about 2 mm. The stamens project 6 mm. from the calyx, which is yellowish with a reddish margin, and 4 mm. long. No pistil is visible. The female flowers are compressed like the ovary; the calyx is

5 mm. by 2 mm. broad, and 3–4 mm. long. Vestigial stamens surround the hair-covered ovary, but their anthers do not dehisce.

Visitors.—Kirchner observed the honey-bee.

635. **A. rubrum** L.—The flower mechanism of this species, which is also native to North America, essentially resembles that of A. dasycarpum (Kirchner, op. cit.).

636. **A. tataricum** L.—Francke states that this species, indigenous to Carniola and Russia, bears male flowers with vestigial ovaries, and female flowers with vestigial stamens. The hermaphrodite flowers are crossed with pollen from male flowers, since their own matures late.

XXXII. ORDER *ANACARDIACEAE* Lindl.

192. **Rhus** Tourn.

Hermaphrodite or unisexual greenish flowers, with exposed nectar secreted by the receptacle. The hermaphrodite flowers are homogamous or often protandrous (Darwin).

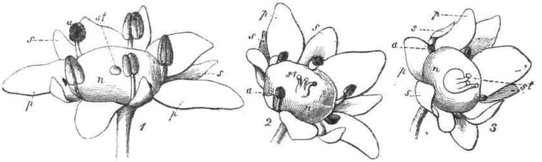


Fig. 80. *Rhus Cotinus, L.* (after Herm. Müller). (1) A purely male flower. (2) A hermaphrodite flower. (3) A purely female flower. *s*, sepals; *p*, petals; *a*, anthers; *st*, stigmas; *n*, nectary.

637. **R. Cotinus** L. (Herm. Müller, 'Fertilisation,' pp. 166–7; Schulz, 'Beiträge,' II, pp. 62–4.)—In this species, according to the observations which Hermann Müller made on garden plants, numerous intermediate stages between purely male, hermaphrodite, and purely female flowers are present on the same stock. The purely male flowers, being the largest, and opening the widest, are the most conspicuous. The female ones are the smallest, and open least, so that they are the most inconspicuous. The flowers are consequently visited in the order best adapted to secure cross-pollination. Schulz, who studied wild plants in the South Tyrol, also observed three distinct forms differing in the development of stamens and carpels. The plants, however, were dioecious, like the cultivated varieties at Halle. Schulz states that there are two series of female flowers, one (diameter $3\frac{1}{4}$–4 mm.) possessing anthers shaped like those of the male flowers, but with abnormal pollen-grains. The stamens of the second form (diameter 3–$3\frac{1}{2}$ mm.), on the other hand, are quite vestigial. The diameter of the male flowers is 5–6 mm. According to Schulz, the distribution of the flowers is dioecious, or more rarely monoecious. In all cases there is a secreting yellow or orange-

coloured disk in the base of the flower, and the nectar lies exposed, so that it is accessible even to very short-tongued insects. Hermann Müller states that visitors chiefly effect cross-pollination in hermaphrodite flowers, owing to the fact that there is a tolerably large interval between anthers and stigmas.

VISITORS.—In Westphalia Herm. Müller chiefly observed Diptera and short-tongued Hymenoptera, but only very few beetles, which do not seem to care much for the dull yellow colour of the flowers. Schulz, on the other hand, saw numerous beetles in the Tyrol, as well as Diptera, wasps, ichneumon-flies, and other short-tongued Hymenoptera. These were so numerous that, on one small bush, he captured 350 individuals belonging to about fifty species in half an hour.

Hermann Müller's list is as follows.—

A. Coleoptera. *Dermestidae*: 1. Andrenus pimpinellae *F.*, nect-lkg. **B. Diptera.** (*a*) *Muscidae*: 2. Calliphora erythrocephala *Mg.*; 3. Lucilia cornicina *F.*, skg.; 4. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 5. Helophilus floreus *L.*, very freq., skg. and po-dvg.; 6. H. pendulus *L.*, do.; 7. Syritta pipiens *L.*, do. **C. Hymenoptera.** (*a*) *Apidae*: 8. Andrena albicans *Müll.* ♀, po-cltg.; 9. Apis mellifica *L.* ☿, skg.; 10. Halictus sexnotatus *K.* ♀, do.; 11. H. sexstrigatus *Schenck* ♀, do. (*b*) *Sphegidae*: 12. Gorytes campestris *L.*, nect-lkg.; 13. Oxybelus uniglumis *L.*, do. (*c*) *Tenthredinidae*: 14. Allantus marginellus *F.*, nect-lkg. (*d*) *Vespidae*: 15. Eumenes pomiformis *F.*, nect-lkg.; 16. Odynerus sinuatus *F.*, do.; 17. O. spinipes *L.*, do.

638. R. typhina L. (Herm. Müller, 'Fertilisation,' p. 167.)—The dioecious flowers of this species are moderately conspicuous, and secrete nectar that is accessible to all.

VISITORS.—Herm. Müller observed certain nect-skg. bees—Apis, Prosopis communis *Nyl.* ♀ and ♂, skg.—and a Neuropterid, Panorpa communis *L.*, skg.

XXXIII. ORDER *LEGUMINOSAE*.

1. SUB-ORDER PAPILIONACEAE.

LITERATURE.—Sprengel, 'Entd. Geh.,' pp. 358–9; Herm. Müller, 'Fertilisation,' pp. 167–220; Delpino, 'Sugli appar. d. fecondaz. nella piante autocarp.,' pp. 24–8, 'Ult. Oss.,' pp. 39–66; Kirchner, 'Flora v. Stuttgart,' pp. 467–8; Loew, in Engler and Prantl, 'D. nat. Pflanzenfam.,' III, 3, pp. 88 et seq.; Knuth, 'Flora v. Schleswig-Holstein,' p. 231, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 53–5, 'Grundriss d. Blütenbiol.,' pp. 40–2.

C. K. Sprengel long ago described the uses of the individual parts of the papilionaceous flower. But he did not understand the various special adaptations presented, and for an explanation of these we are indebted to F. Delpino and Hermann Müller. In the following descriptions the admirable accounts of the latter will be followed so far as possible. All the papilionaceous species indigenous to Germany bear homogamous, rarely slightly protandrous bee flowers[1] (in the wider sense).

The characteristically shaped, usually brightly coloured flowers are often aggregated into very conspicuous racemose, or capitulate inflorescences, admirably adapted

[1] For this reason the Hymenoptera will be placed first in some of the lists of visitors.

to attract insects. Their power of attraction is often enhanced by more or less marked fragrance. The gamosepalous calyx holds the petals erect, in a position adapted to the insect visitors. The vexillum serves in the bud to cover the inner parts of the flower. In the open blossom it is erect and acts as a signboard; it often possesses nectar-guides in the form of colour-streaks. The vexillum is also used as a support by bees, which press their heads against it as they suck. The alae have a threefold function.—1. They serve as a resting-place for bees; 2. They act as levers, depressing the carina, so that the stigma and pollen protrude during insect-visits, and are brought into contact with the under-sides of the visitors (bees); 3. They hold the carina in place as regards stamens and pistils, and after the departure of a visitor help these parts to regain their original position. The carina is a protective structure, sheltering the stamens and pistil from rain, and keeping away unbidden guests (Lepidoptera and flies). When all ten filaments cohere, the flowers afford only pollen, but when the upper one is free, there is a slit on either side of it, leading to the nectar secreted inside the bases of the stamens. The closed or split cylinder formed by the filaments envelops the pistil, of which the style is usually upwardly curved at the tip, and projects somewhat beyond the anthers, so that the stigma first protrudes from the carina when an insect visits the flower, and first touches its under-side. Cross-pollination therefore results if the insect has previously visited another flower of the same species. In some species the stigma is completely covered by the pollen of the same flower, but self-fertilization does not usually follow, for it only becomes receptive after visitors have rubbed against its papillae.

In our native Papilionaceae Delpino distinguishes four types of flower mechanism connected by transitional forms.—

1. Simple valvular arrangement. Stamens and pistil project from the carina as long as the pressure of the bee continues, and then return to their former position. Such flowers permit of a number of effective visits.

(*a*) Nectar: Melilotus, Trifolium, Galega, Onobrychis, Astragalus, Oxytropis, Phaca, Ornithopus, Hedysarum.

(*b*) Enclosed sap, reached by boring: Cytisus (some of the species are transitional to 3 (*a*)).

2. Explosive arrangement. Stamens and pistil suddenly spring out of the carina. Such flowers permit of only one effective visit.

(*a*) Nectar present: Medicago.

(*b*) No nectar.

(*α*) The ventral surface of the bee comes into contact with the pollen and stigma: Genista, Ulex.

(*β*) The bee is struck on the back by the pollen and stigma: Sarothamnus.

3. Pump arrangement. The thickened ends of the filaments press out the pollen in successive portions from the tip of the carina. Several insect-visits are necessary for pollination.

(*a*) Nectar present: Lotus, Anthyllis, Tetragonolobus, Hippocrepis.

(*b*) No nectar: Ononis, Lupinus, Coronilla.

4. Brush arrangement. A brush of hairs on the style sweeps the pollen out from the tip of the carina. Here again repeated insect-visits are usually necessary for pollination.

(*a*) The tip of the style is straight: Lathyrus, Pisum, Vicia, Lens, Robinia.

(*b*) The tip of the style is helicoid: Phaseolus.

Papilionaceae possessing the brush arrangement are divided by Taubert (in Engler and Prantl, 'D. nat. Pflanzenfam.,' III, 3, p. 92) into two subdivisions, according as the sweeping apparatus acts exactly in the median plane of the flower or not. In the former case the pollen is deposited on the ventral surface of the visitor ('pollinazione sternotriba,' Delpino), e.g. in Vicia Cracca, V. sepium, V. Faba, and also in Pisum sativum, which shows a combination of the pump and brush arrangements. In the second case the brush emerges laterally and obliquely, not in the median plane of the flower, so that the pollen can only be deposited on the right or left side of the body of the visitor ('pollinazione pleurotriba,' Delpino). An indication of a unilateral mechanism of the kind occurs in some species of Lathyrus (L. sylvestris, L. grandiflorus), while other species of the same genus (e.g. L. pratensis) have a median pollinating apparatus. The asymmetry is more marked in species of Phaseolus (P. vulgaris, P. multiflorus), in which it is conditioned by the helicoid spiral of the tip of the style. In P. Caracalla this coiling of the style is most pronounced, as there are 4–5 turns in the spiral.

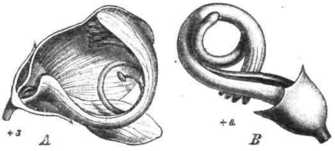


FIG. 81. *Apios tuberosa, Moench* (after Taubert and Loew). *A*. Flower seen from the side after removal of half the calyx, half the vexillum, and the right ala (×3). *B*. Sexual apparatus after removal of the corolla; the stamens project on the right side and the style on the left (× 4).

Apios tuberosa presents a transition to flower mechanisms of other kind, particularly characteristic of extra-European species. Here, according to Loew (Flora, Marburg, lxxiv, 1891), the sickle-shaped tip of the carina is held fast in a cap-shaped protuberance of the vexillum in such a way as to render impossible the movements which usually take place in papilionaceous flowers, so that cross-pollination has to be secured in another way (see Fig. 81).

The species of Erythrina exhibit still another modification in the construction of the flower. In E. Crista-galli, according to Hildebrand (Bot. Ztg., Leipzig, xxviii, 1870), the flower is so twisted that the pollinating apparatus is upside down, while at the same time the alae and carina are much reduced. The latter forms a stiff, immobile sheath, which surrounds the markedly projecting sexual organs above, and expands below into a nectar-receptacle. Delpino supposed that species of Trochilus and Nectarinia acted as pollinators. This supposition has been confirmed by the direct observations of Scott-Elliot, who saw species of Nectarinia on F caffra *Thunb.* He further states that E. Indica *Lam.* and Sutherlandia frutescens *R. Br.* are also ornithophilous. The alae and carina are entirely suppressed in Amorpha

fruticosa, which, according to Hermann Müller ('Weit. Beob.,' pp. 244–5), is also distinguished by its protogyny from the other Papilionaceae, these being typically homogamous or protandrous (Taubert, op. cit.).

Kuhn states (Bot. Ztg., Leipzig, xxv, 1867) that some genera include species with cleistogamous flowers, e. g. Arachis *L.*, Chapmannia *Torr. et Gray*, Heterocarpaea *Phil.*, Lesperdeza *Rich.*, and Stylosanthes *Swartz.*

The following Papilionaceae have so far been recognized as self-sterile:—Trifolium pratense, T. repens, T. incarnatum; Phaseolus multiflorus, Lathyrus grandiflorus, Vicia Faba, Erythrina sp., Sarothamnus scoparius, Melilotus officinalis, Lotus corniculatus, Cytisus Laburnum (Darwin), Astragalus alpinus (Axell), Wistaria sinensis (Gentry).

193. **Sarothamnus** Wimm.

Yellow, homogamous, hymenopterid flowers devoid of nectar; with explosive mechanism and spirally coiled style. Only one effective visit possible.

639. S. scoparius Koch (=Spartium scoparium *L.*). (Darwin, Proc., Linn. Soc., London, 1867, p. 358; Herm. Müller, 'Fertilisation,' pp. 195–8, 'Weit. Beob.,' II, p. 257; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 329–32; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 55–6, 152, 'Bloemenbiol. Bijdragen.')—The flower mechanism of this species can only be liberated by humble-bees and the honey-bee; while smaller and less skilful Apidae, as well as a few Syrphidae and beetles, are merely found collecting or devouring the pollen of already exploded blossoms. The mechanism is described by Hermann Müller somewhat as follows.—

Insects are attracted by the large yellow flowers, and although these are nectarless the vexillum is marked with streaks which converge below so that the presence of nectar is suggested to insects. When a honey-bee settles upon a flower that has not yet been visited, it grasps the alae with its middle and hind-legs, and pushes its fore-legs and head under the middle of the vexillum. The alae are therefore pressed forcibly down, and also the carina, of which the proximal third is united with them by interlocking folds. The free upper edges of the carina consequently begin to separate from base to tip, and as soon as they have half done so, the five shorter stamens, which even in the bud dehisce upwards, spring up and scatter some of their pollen on the ventral surface of the bee, without disturbing it in its work. The cleft now rapidly extends towards the tip of the carina till it reaches the point where the tip of the style presses against the united part of the carinal petals, when a second and much more violent explosion takes place. Until then the long style lies like a stretched spring in the carinal cavity, the extremity of which it fills, while its end is pressed against the tip of the carina. Scarcely, therefore, have the edges of the carina separated as far as this point, when the style shoots out, and strikes the back of the bee with its papillose tip. Immediately afterwards, most of the pollen swept out by the lamelliform part of the style is thrown upon the back of the insect, while at the same time the five long stamens, which have long since dehisced, bend inwards and spring out of the carina. The visitor now frees itself from the style, which has usually coiled round it, and collects the pollen still adhering to the anthers. This is so abundantly

present that despite the absence of nectar, and the whip-like action of the style, the bee continues to visit other flowers.

While the honey-bee is obliged to make considerable efforts before it can effect explosion, the stronger and heavier humble-bees (Bombus terrester and B. lapidarius) do this with the greatest ease.

Cross-pollination takes place because the style springs out of the carina a moment sooner than the stamens, so that the stigma of the second flower visited is dusted with foreign pollen. Even the first flower visited will very probably be crossed, though its own pollen lies all around, for the style rolls up to such an extent that the stigma once more faces upwards, so that subsequent visitors may still effect cross-pollination. The honey-bee and humble-bees hardly ever settle on exploded flowers, which are almost exclusively visited by smaller bees, hover-flies, or flower-beetles. Failing visits from humble-bees or the honey-bee, explosion does not take place. Darwin states that in this case the flowers remain unfertilized.

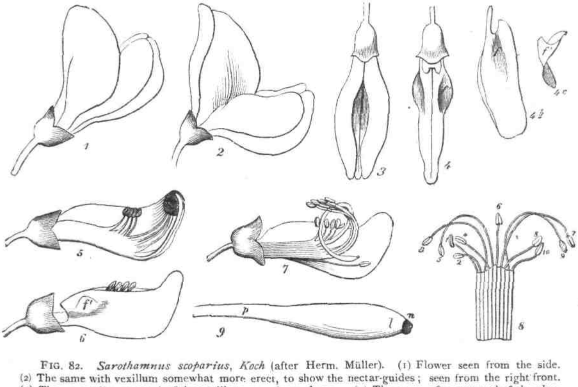


FIG. 82. *Sarothamnus scoparius, Koch* (after Herm. Müller). (1) Flower seen from the side. (2) The same with vexillum somewhat more erect, to show the nectar-guides; seen from the right front. (3) The same after removal of the vexillum, seen from above. (4) The same, after removal of the alae. *(4 b) The left ala, seen from the inner side, showing the fold f, which* lies upon a projection (4 *c* and 6 *f'*) of the carina. (4 *c*) The projection of the carina, seen from the front. (5) Position of the stamens and pistil in the unexploded flower. (6) Flower after explosion of the short stamens and removal of the vexillum and alae; seen from the side. (7) Position of the parts after explosion. (8) Staminal tube, split longitudinally to the right of the posterior stamen (1) and spread out. (9) End of the style with the stigma (*n*) seen from the inner side; *pl*, the plate which scatters the pollen.

VISITORS.—Only strong eutropous bees with a long proboscis (Apis, Bombus, Eucera) are able to set the flower mechanism in motion. Other bees (mostly hemitropous), po-dvg. hover-flies, and po-dvg. beetles, can only, as already stated, plunder flowers that have already exploded.

Hermann Müller (H. M.) in Westphalia, Loew (L.) in Brandenburg, Alfken (A.) in Bremen, Verhoeff (V.) in Norderney, and myself (Kn.) in Schleswig-Holstein have observed the following bees, all po-dvg., as legitimate visitors.—

1. Apis mellifica *L.* ☿ (H. M., A., Kn.); 2. Bombus agrorum *F.* ♀, infrequent (A., Kn.); 3. B. distinguendus *Mor.* ♀, freq. (A.); 4. B. lapidarius *L.* ♀ (H. M., V., Kn.); 5. B. hortorum *L.* (A., Kn.); 6. B. muscorum *F.* ♀, freq. (A.); 7. B. terrester *L.* ♀ (H. M., V., Kn.); 8. Eucera longicornis *L.* ♂ (L.).

H. de Vries saw the honey-bee in the Netherlands, and MacLeod noticed Apis, 3 humble-bees, 3 Andrenae, and 3 hover-flies in Flanders. In Dumfriesshire, Apis, a humble-bee, and several Diptera have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 42). In England Saunders observed Eucera longicornis *L.* with its parasite Nomada sexfasciata *Pz.*

As unbidden guests, Hermann Müller observed bees (Andrena fulvicrus *K.* ♀, Halictus zonulus *Sm.* ♀, Osmia fusca *Chr.* ♀), hover-flies (Rhingia rostrata *L.*), and beetles (Anthobium abdominale *Gr.*, A. florale *Gr.*, and Meligethes). In Wiesbaden Rössler noticed moths — Trifurcula immundella *Z.*, Fidonia famula *Esp.*, and Threnodes pollinalis *Schiff.* In Westphalia and East Prussia von Fricken saw the Curculionids Bruchus villosus *F.* and Tychius venustus *F.* destroying the flowers, and the Chrysomelids Cryptocephalus vittatus *F.* and Gonioctena olivacea *Forst.*, po-dvg.

194. **Spartium** L.

640. **S. junceum** L.—There is an explosive mechanism in this species.

Visitors.—Delpino ('Ult. oss.,' I) more particularly noticed the carpenter bee, Xylocopa violacea *L.* At Pola Schletterer observed 3 bees—1. Andrena flavipes *Pz.*, 2. A. morio *Brull.*, and 3. the mason bee Megachile muraria *L.*, the last as 'one of the few nectar-loving guests.'

195. **Genista** L.

Yellow, homogamous, nectarless bee flowers; with an explosive mechanism. The stamens and pistil come into contact with the ventral surface of the visiting bees. Only one effective visit is possible. More rarely there is a simple valvular arrangement.

641. **G. tinctoria** L. (G. Henslow, J. Linn. Soc. Bot., London, x, 1869; Herm. Müller, 'Fertilisation,' pp. 188–92, 'Weit. Beob.,' II, p. 257; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 332–3; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 56–7, 152, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 232.)—The yellow flowers of this species are associated in racemes, and devoid of nectar and nectar-guides. The two pentamerous whorls of stamens, and the projecting style, are closely surrounded by the carina. The anthers of the four upper stamens of the outer whorl dehisce in the bud, discharging their pollen into the carina, while their filaments shrivel. This pollen remains lying above the style, and is pushed into the tip of the still growing carina by the elongation of the five inner stamens. Shortly before the vexillum unfolds the pollen of the six undehisced stamens is discharged, so that now the upper part of the carina closely surrounds all the pollen, and the lower part the style. The latter and the staminal tube together make up a stretched spring exerting an upward pressure, while the claws of the carinal petals and the interlocked alae constitute a second spring which presses downwards. These opposing forces are in equilibrium, and the parts concerned remain horizontal,

until the upper edges of the carinal petals are caused to separate. Each ala possesses a fold which interlocks with an acutely angular projection on the upper margin of the corresponding half of the carina. It therefore follows that when a bee settles on the flower, resting with its limbs on the alae, and thrusting its head under the vexillum, the alar folds slip down the column formed by the filaments and the pistil, and at the same time the carina splits open above from base to tip. When the splitting has extended as far as the end of the style, the stretched parts suddenly separate, the carina and alae moving down, the style with its superimposed pollen springing up. The stigma thus first touches the ventral surface of the bee, and if this has previously visited another flower of the same species it gets pollinated. Immediately afterwards the pollen is pressed against the under-side of the visitor. If cross-pollination is not effected, self-pollination is

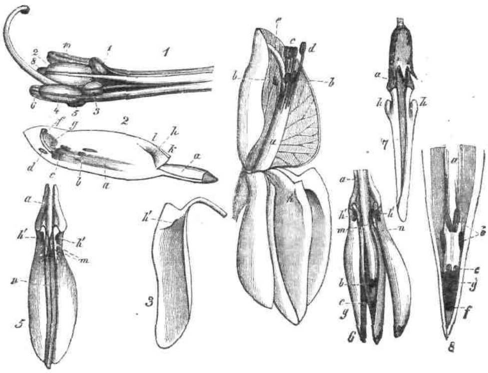


FIG. 83. *Genista tinctoria*, *L.* (after Herm. Müller). (1) The stamens with style and stigma; taken from a bud. (2) Position of the parts enclosed in the carina in a flower not yet visited by insects. (3) Right ala, seen from within. (4) Exploded flower. (5) Unexploded flower, after removal of calyx and vexillum; seen from above. (6) The same, after the carina has been split open almost to the tip by pressure from above. (7) Unexploded flower, after removal of vexillum and alae; seen from above (8) Anterior part of a flower split open and about to explode; seen from above (enlarged to twice the scale of the other figures). *a*, stamens with style and stigma; *b*, the four outer stamens that have remained short (2, 4, 8, 10 in Fig. 1); *c*, the five inner stamens (1, 3, 5, 7, 9); *d*, the outer stamen (6) that lies under the style; *e*, tip of the style; *f*, stigma; *g*, pollen; *h*, lateral projections of the carina, with which corresponding alar folds (h^1) interlock; *kl*, that part of the upper margin of the carina which is split before explosion; *m*, alae; *n*, carina.

brought about by the insect as it backs out of the flower. Explosion has not been observed to occur without the application of external pressure.

VISITORS.—*According to Hermann Müller*, the visitors are chiefly pollen-collecting bees, which sometimes also vainly seek for nectar. All of them, even the nectar-seeking males, bring about explosion, and effect pollination in the way already described. Among useless visitors are wasps, Conopidae, Syrphidae, Lepidoptera, and destructive beetles which gnaw the flowers (Cryptocephalus).

I have so far observed Apis and some humble-bees (Bombus cognatus *Steph.*, B. lapidarius *L.*, B. terrester *L.*) in Schleswig-Holstein.

Hermann Müller's list of visitors is as follows.—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Cryptocephalus moraei *L.*, gnawing the flowers; 2. C. sericeus *L.*; 3. C. vittatus *F.* (*b*) *Elateridae*: 4. Agriotes gallicus *Lac.*, vainly skg.; 5. A. ustulatus *Scholl.*, do. **B. Diptera.** (*a*) *Conopidae*: 6. Myopa testacea *L.*, vainly skg.; 7. Sicus ferrugineus *L.*, do. (*b*) *Syrphidae*: 8. Chrysotoxum bicinctum *L.*, vainly skg. **C. Hymenoptera.** (*a*) *Apidae*: 9. Andrena albicrus *K.* ♂, po-cltg.; 10. A. fulvescens *Sm.* ♂, do.; 11. A. fulvicrus *K.* ♀, do.; 12. A. xanthura *K.* ♀, do.; 13. Anthidium punctatum *Latr.* ♂, vainly seeking for nectar, po-cltg.; 14. Apis mellifica *L.* ☿, freq., po-cltg.; 15. Bombus terrester *L.* ♀, po-cltg.; 16. Colletes daviesanus *K.* ♀, do.; 17. Diphysis serratulae *Pz.* ♂, do.; 18. Halictus albipes *F.* ♀, do.; 19. H. rubicundus *Chr.*, do.; 20. Megachile centuncularis *L.* ♀, very freq., po-cltg.; 21. M. circumcincta *K.* ♀, do.; 22. M. versicolor *Sm.* ♀, po-cltg.; 23. M. willughbiella *K.* ♀, do.; 24. Osmia platycera *Gerst.*, do. (*b*) *Vespidae*: 25. Odynerus trifasciatus *F.* ♀, po-dvg. **D. Lepidoptera.** 26. Lycaena damon *S. V.*; 27. Melitaea athalia *Rott.*; 28. Pararge megaera *L.*, vainly seeking for nectar.

Rössler observed a moth, Grapholitha scopariana *H.-S.* at Wiesbaden.

In Dumfriesshire two humble-bees were noticed (Scott-Elliot, 'Flora of Dumfriesshire,' p. 42).

642. G. germanica L.—Kirchner ('Flora v. Stuttgart,' pp. 473–4) states that the flower mechanism resembles that of the last species, but in this case there is no explosion by release of parts in a state of tension. The stamens and style protrude from the carina on the application of pressure, so that there is a simple valvular arrangement. There is a slit in the upper side of the carina, extending right to its tip, and just in front of the claw of either carinal petal there is a rounded prominence which fits into a pouch in the corresponding ala. The anthers are disposed in two sets in the bud, one close behind the other, and the hooked inwardly bent style projects beyond them. They dehisce before anthesis. The anterior surface of the style is pressed against the inner wall of the carina, so that there is a certain amount of strain—though this is inconsiderable—between the style and stamens on the one hand and the carina on the other. In this stage the vexillum is still folded down on the alae and carina, and as the stigma is already mature automatic self-pollination must take place, according to the above account. As the vexillum erects itself the backwardly-curved style elongates, and projects from the tip of the carina of the horizontal flower. Insect visitors must, therefore, first touch the stigma as they alight, and will effect cross-pollination if they have previously visited another flower. During the first visit almost all the pollen is at once discharged from the depressed carina. If the carina is only slightly pressed down it returns slowly to its original position when the pressure is removed, owing to the slight elasticity of its interlocking projections. But if it is so far depressed by heavier and more powerful insects that these projections are brought right under the style, a return to the first position is impossible. Such flowers look like the exploded blossoms of G. tinctoria.

Visitors.—I observed Bombus lapidarius *L.* ♀ in Schleswig-Holstein ('Bloemenbiol. Bijdragen').

643. **G. sagittalis** L.—Kirchner ('Flora v. Stuttgart,' p. 474) states that, like G. germanica, this species possesses a simple non-explosive valvular mechanism. The column, made up of style and stamens, protrudes from the carina during insect-visits, moving back again when the pressure is removed. The anthers dehisce in the bud, and as the slightly up-curved style extends but little beyond them at this stage the stigma is self-pollinated. After the vexillum has become erect, the style, which is still bent slightly upwards, projects about 1 mm. beyond the anthers, so that when a bee settles on the flower the stigma first projects from the carina and touches its ventral surface. The second flower visited by an insect is therefore cross-pollinated. Should considerable pressure be exerted, the carina remains depressed as in G. germanica.

VISITORS.—Kirchner observed undetermined species of Apidae. Schenck saw two sternotribous bees, i.e. Megachile circumcincta *K.* and Trachusa serratulae *Pz.*

644. **G. anglica** L.—In this species, which was first thoroughly described by Hermann Müller ('Fertilisation,' pp. 192–3), the opposite tensions of style and stamens on the one hand, and of the carina and alae on the other, are much less pronounced. The carina and alae sink down but little when explosion takes place, and only the style curves upwards, its tip at the same time curling inwards.

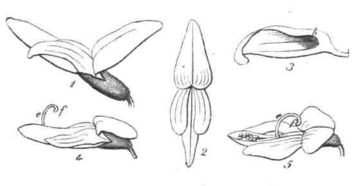


FIG. 84. *Genista anglica, L.* (after Herm. Müller). (1) Unvisited flower, seen from the side. (2) The same, seen from the front. (3) Right ala, seen from the inner side. (4) An exploded flower, with the style curved back less than usual. (5) A flower that has exploded normally, seen from the left. *e*, tip of style; *f*, stigma; *h*, alar fold.

VISITORS.—Herm. Müller observed the honey-bee as a visitor. This almost exclusively visited unexploded flowers, assuming a position as if it would suck concealed nectar from their bases, and filling its pollen-baskets with its second legs. Herm. Müller also repeatedly saw two short-tongued bees po-cltg., i.e. Andrena fulvicrus *K.* ♀ and Halictus cylindricus *F.* ♀.

Alfken and Höppner (H.) observed the following bees at Bremen.—

1. Andrena nigro-aenea *K.* ♀, infrequent, po-cltg.; 2. A. convexiuscula *K.* ♀, po-cltg.; 3. Apis mellifica *L.* ☿, do.; 4. Bombus muscorum, *F.* ♀; 5. B. terrester *L.* ♀; 6. Halictus flavipes *F.* ♀, freq., po-cltg.; 7. H. leucopus *K.* ♀; 8. H. rubicundus *Chr.* ♀, freq., po-cltg.; 9. Osmia uncinata *Gerst.* ♀, one individual, po-cltg.; 10. Nomada alternata *Pz.* ♀ (H.); 11. N. succincta *Pz.* ♀ (H.).

In Amrum and Föhr, I only saw the honey-bee ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 152).

In Föhr and Sylt, I observed a moth (Zygaena filipendulae *L.*), as an unbidden guest, vainly trying to suck.

645. **G. pilosa** L.—The flower mechanism of this species agrees completely with that of G. anglica. It was first described by Delpino ('Ult. oss.,' pp. 48–52). He found that the flowers are self-sterile.

Visitors.—Herm. Müller ('Fertilisation,' p. 193) in Westphalia, and myself in Föhr and Amrum, observed the honey-bee.

At Wiesbaden Rössler noticed the moth Threnodes pollinalis *S. V.* as an unbidden guest.

196. Ulex L.

As the last genus.

646. U. europaeus L. (Ogle, Pop. Sci. Rev., London, ix, 1870, pp. 164–5; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892, pp. 101 et seq.; Knuth, 'Bloemenbiol. Bijdragen.')—Ogle states that the flower mechanism of this species agrees with that of G. tinctoria, and Kerner also describes it as an explosive arrangement. But, according to my own observations, the contrary tensions of stamens and style on the one hand, and carina and alae on the other, are not so strong, so that the mechanism much more closely resembles those of G. anglica and G. pilosa.

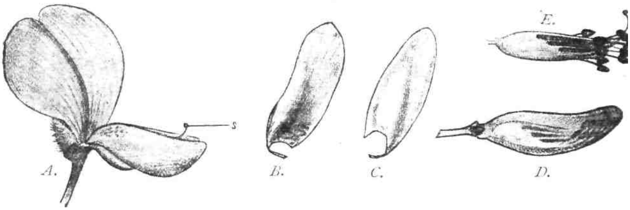


Fig. 85. *Ulex europaeus, L.* (from nature). *A.* Exploded flower; *s*, stigma. *B, C.* An ala, seen from within and without. *D.* Stamens and pistil enclosed in the carina, and seen by transparency. The style is bent like a spring, so that the stigma is pressed against the cohering upper edges of the carinal petals. *E.* The same, removed from the carina.

The carina and alae are only united together at one point on the upper side of their claws, where some of the epidermal cells interlock; and an alar projection fits into a carinal pit on either side. The union is so slight that the petals can easily be separated without tearing.

Although explosion is but feeble, the pollen is so completely discharged on to the ventral surface of the visiting bee, that when this has flown away scarcely a single grain can be found upon the anthers.

Visitors.—In the island of Föhr ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 85) I saw numerous well-developed fruits, indicating insect-visits, although I never actually observed these. The size of the flowers suggested that humble-bees were the pollinators. And I actually noticed Bombus terrester *L.* ♀ as a visitor at Kiel (May 9 and 23, 1896). I also saw Meligethes as an unbidden guest. In Flanders, MacLeod noticed Apis, Bombus terrester *L.* ♀, 2 Halictus, and 2 flies (the last four only on exploded blossoms) (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 329).

Burkill observed the following on the Yorkshire coast ('Fertlsn. of Spring Fls.').—

A. Araneidae. 1. Philodromus aureolus *Clerck*, lurking on unexploded flowers and the central parts of exploded ones. **B. Coleoptera.** 2. Apion ulicis *Forst.*; 3. Meligethes picipes *Sturm*, po-dvg.; 4. Cryptophagus vini *Panz.*, po-dvg. and searching for nectar. **C. Diptera.** (*a*) *Muscidae*: 5. Hylemia sp., searching for nectar; 6. Lucilia cornicina *F.*, do.; 7. Sepsis nigripes *Mg.*, do. (*b*) *Syrphidae*: 8. Eristalis arbustorum *L.*, po-dvg.; 9. E. pertinax *Scop.*, searching for nectar; 10. Melanostoma quadrimaculata *Verral*, po-dvg. **D. Hymenoptera.** *Apidae*: 11. Andrena clarkella *K.*, po-cltg.; 12. Apis mellifica *L.* ☿, po-cltg. and at times searching for nectar; 13. Bombus lapidarius *L.*, searching for nectar; 14. B. terrester *L.*, do. and po-cltg. **E. Thysanoptera.** 15. Thrips sp., very freq.

197. Cytisus L.

Yellow, homogamous to protandrous, monadelphous bee flowers; with sap enclosed in the tissues of the base of the flower, requiring to be bored for. The pressure exerted by a visitor causes stamens and pistil to protrude from the carina, to which they return when the pressure ceases. Several effective visits are therefore possible. In some species there is a transition to a pumping arrangement. (Cf. C. nigricans.)

647. C. Laburnum L. (Herm. Müller, 'Fertilisation,' pp. 193–5; Kirchner, 'Flora v. Stuttgart,' pp. 475–6; Knuth, 'Bloemenbiol. Bijdragen.')—The flowers of this species are of considerable size, and aggregated into conspicuous many-blossomed inflorescences. Kerner says that when they open the pedicels twist round so as to turn the vexillum upwards and the carina downwards. The insertion of the vexillum is bounded in front by a thick fleshy swelling, full of sweet sap. As nectar-guides, the vexillum possesses dark streaks, converging basally to this swelling, from which nectar is obtained by boring. The union of alae and carina is but slight, and is effected by a flattish alar projection, which fits into a corresponding carinal pit on either side.

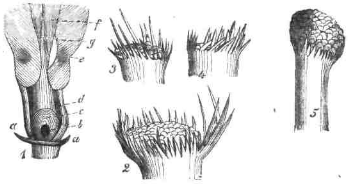


FIG. 86. *Cytisus Laburnum*, *L.* (after Herm. Müller). (1) Basal part of an older flower, after removal of calyx and vexillum; seen from above: *aa*, cut surface of calyx; *b*, insertion of vexillum; *c*, the nectar-yielding swelling, into which insects appear to bore; *d*, claw of ala; *e*, flat projection of ala, which fits into a corresponding pit on the upper side of the carina; *f*, carina; *g*, open slit of the same. (2, 3, 4) Stigmas of younger flowers. (5) Stigma of an older flower.

Towards the end of the bud-period the stigma lies in the tip of the carina, surrounded by stiff, glassy, erect hairs, that project beyond it, and at the beginning of anthesis bend somewhat over its papillae, which are thus guarded from contact with the under-sides of insect visitors. These hairs gradually shrivel up, so that in older flowers the papillae are quite uncovered. At the same time the style curls more and more inwards, and stretches out to an increasing distance through the open cleft of the carina, so that insect visitors first touch the stigma, and cross-pollination is ensured. Automatic self-pollination is excluded.

VISITORS.—Hermann Müller saw po-cltg. bees, most of which also bored for nectar (Bombus lapidarius *L.* ♀ and ☿, skg. and po-cltg.; B. terrester *L.* ♀, skg.; Andrena albicans *Müll.* ♀, po-cltg.; A. tibialis *K.*; A. xanthura *K.* ♀, po-cltg.; Apis mellifica *L.* ☿, freq., po-cltg.), also moths (Plusia), skg.; and Meligethes, creeping about the flowers. He noticed both bees and butterflies that, not merely in one flower but in several successively, inserted their proboscis under the vexillum, and remained in this attitude for some time. Under such circumstances the collecting apparatus of the bees remained quite empty after repeated visits. From this it may be concluded that bees and butterflies actually perforate and suck the nectariferous swelling.

In Kiel Botanic Garden, I saw (May 21, 1896) the just-opened flowers of laburnum visited by our three commonest humble-bees, po-cltg. (Bombus hortorum *L.* ♀, B. terrester *L.* ♀, B. lapidarius *L.* ♀).

Alfken observed the following bees at Bremen, all skg.—

1. Bombus agrorum *F.* ♀; 2. B. hortorum *L.* ♀; 3. B. ruderatus *F.* ♀; 4. Psithyrus vestalis *Fourcr.*

648. C. decumbens Spach.—According to Briquet ('Études de biol. flor. dans les Alpes occident.'), the flowers of this species are nectarless, and possess an explosive mechanism which acts but once. It is set free by humble-bees, and cross-pollination often results. Automatic self-pollination takes place in wet weather (Kirchner).

649. C. hirsutus L.—

VISITORS.—Schletterer records the bees Podalirius acervorum *L.*, and P. tarsatus *Spin.*, for the Tyrol.

650. C. nigricans L.—Hermann Müller describes ('Weit. Beob.,' II, pp. 254–6) the flower mechanism of the golden yellow flowers of this species as being an intermediate stage between the pumping arrangement of Lotus (*vide supra*), and the simple valvular arrangement of C. Laburnum. The alae enclose the uppermost part of the carina, which narrows into a sharp edge, and are slightly convex externally. Their lower margins rest on the expanded sides of the carina. In the young bud the five very large outer stamens (i. e. those alternating with the petals) project completely beyond the five very small inner stamens (superposed upon the petals). The anthers of the large stamens dehisce before anthesis, and quickly shrivel, so that their pollen lies loosely between them, surrounded only by the carina. The tips of the filaments of the small stamens have so far been bent inwards, but they now straighten themselves, forcing their anthers between those which have already dehisced, and pushing the pollen shed by these into the empty upwardly-bent tip of the carina. The thickened outer filaments are stiff, and when the carina is depressed push out the pollen through the opening at its apex. These filaments therefore act as piston-rods, while the small anthers, filling as they do the lower part of the pollen receptacle, serve as pistons. In a young flower, depression of the carina—the upper edges of which are closely apposed—causes some pollen to be squeezed out of its apex, so that it will adhere to the under-side of an insect visitor. But, in older flowers, the upper carinal edges are so loosely in contact that when the carina is depressed it opens widely, allowing

stamens and stigma to protrude. It follows that pollen-collecting insects will carry the pollen of younger flowers to the stigmas of older ones, and thus effect crossing.

Visitors.—In the Oberpfalz, Herm. Müller only saw a po-cltg. bee—Andrena xanthura *K.* ♀. In Steiermark, E. Loew observed a long-tongued bee—Megachile sp., po-cltg.; and Hoffer the humble-bee Bombus mastrucatus *Gerst.* ♀.

651. **C. sagittalis** Koch. (Herm. Müller, 'Weit. Beob.,' II, p. 254.)—

Visitors.—These are po-cltg. bees. Herm. Müller saw the following in the Vosges.—

1. Andrena convexiuscula *K.* ♀; 2. Bombus lapidarius *L.* ☿; 3. B. terrester *L.* ♀; 4. Halictus rubicundus *Chr.* ♀; 5. Osmia fulviventris *Pz.* ♀.

Buddeberg observed the following in Nassau.—

1. Bombus variabilis *Schmiedekn.*, var. tristis *Seidl.* ☿; 2. Diphysis serratulae *Pz.* ♂; 3. Megachile circumcincta *K.* ♀.

Rössler noticed the following Lepidoptera as unbidden guests at Wiesbaden.—

1. Grapholitha asseclana *Hb.*; 2. G. fuchsiana *Rsslr.*; 3. G. succedana *Fröl.*; 4. Threnodes pollinalis *S. V.*

652. **C. canariensis** Steud., and 653. **C. albus** Link.—The flowers of these species possess an explosive mechanism, in which the anthers are at first slightly depressed with the carina, and then spring out above. Hildebrand considers it an adaptation to self-pollination, because some of the scattered pollen reaches the stigma of the same flower (Bot. Ztg., Leipzig, xxiv, 1866, p. 75). It appears very probable that cross-pollination is favoured by insect-visits.

654. **C. austriacus** L.—

Visitors.—Loew observed a humble-bee, Bombus agrorum *F.*, po-cltg., in the Berlin Botanic Garden.

198. Sophora L.

655. **S. flavescens** Ait.—

Visitors.—Loew observed Bombus terrester *L.* ♂, skg., in the Berlin Botanic Garden.

199. Thermopsis R. Br.

656. **T. fabacea** DC.—

Visitors.—Loew observed Bombus hortorum *L.*, skg., in the Berlin Botanic Garden.

200. Lupinus Tourn.

Yellow, blue, or white, nectarless bee flowers, with a pumping arrangement *from which strings of pollen are extruded.*

657. **L. luteus** L. (Herm. Müller, 'Fertilisation,' pp. 187–8; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen.')—The dark yellow flowers of this species are devoid of nectar but very fragrant. Hermann Müller describes the alae as being united together by fusion of their anterior margins, while each of them is interlocked with the carina by a latero-basal fold fitting into a corresponding depression. The anthers of the five outer stamens are very much larger

than those of the five inner, and dehisce before anthesis, after which they completely shrivel up. Their pollen is stored up in the hollow cone constituted by the tip of the carina. The five inner stamens, which have so far remained short, now begin to grow actively, and compress the pollen in the end of the carina. During insect-visits they act as pistons, by which a string of pollen is squeezed out from the carinal apex. When the weight of the visitor is removed, the alae and carina return to their old position, so that further visits cause more pollen to be extruded. At a later stage the stigma also protrudes, and visitors carrying pollen from younger flowers will therefore effect crossing. As in Cytisus Laburnum, automatic self-pollination is prevented, or at any rate hindered, by a circlet of stiff erect hairs.

VISITORS.—Herm. Müller saw three po-cltg. bees.—1. Apis mellifica *L.* ☿, freq.; 2. *Bombus lapidarius L.* ☿, *occasional; 3. Megachile circumcincta K.* ♀. *The two* first of these I noticed in Mecklenburg, and also Bombus terrester *L.* ☿, po-cltg. In Rügen I observed the following.—

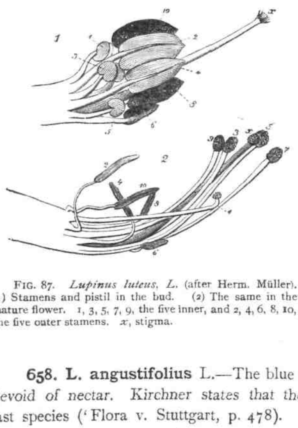


FIG. 87. *Lupinus luteus, L.* (after Herm. Müller). (1) Stamens and pistil in the bud. (2) The same in the mature flower. 1, 3, 5, 7, 9, the five inner, and 2, 4, 6, 8, 10, the five outer stamens. *x*, stigma.

A. Hymenoptera. *Apidae*: 1. Apis mellifica *L.* ☿, skg. and po-cltg., with large masses of orange-coloured pollen in its baskets; 2. Bombus agrorum *F.* ☿, skg.and po-cltg. **B. Lepidoptera.** *Rhopalocera*: 3. Argynnis paphia *L.*, skg., an unbidden guest.

Alfken saw the humble-bee Bombus lapidarius *L.* ♀ in Bremen, and Loew the following bees in Silesia ('Beitrage,' p. 34).—

1. Bombus cognatus *Steph.* ☿, po-cltg.; 2. B. rajellus *K.* ☿, do.; 3. Megachile maritima *K.* ♀, do.

658. L. angustifolius L.—The blue flowers of this species are odourless and *devoid of nectar. Kirchner states that their mechanism agrees with that of the* last species ('Flora v. Stuttgart, p. 478).

VISITORS.—I noticed the same bees in Mecklenburg as for the last species.

659. L. polyphyllus Lindl.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Andrena dorsata *K.* ♀, transferring pollen pumped out from the carina to the tibial and tarsal brushes of its hind-legs; 2. Anthidium manicatum *L.* ♀, po-cltg. and trying to suck in spite of the absence of nectar, ♂ swarming about the flowers; 3. Apis mellifica *L.* ☿, cltg. the extruded pollen, and vainly skg.; 4. Megachile centuncularis *L.* ♀, do.; 5. M. circumcincta *K.* ♀, do.; 6. M. ericetorum *Lep.* ♀, do., ♂, vainly skg.; 7. *Osmia aenea L.* ♀, *do.*

I saw the humble-bee Bombus lapidarius *L.* ♂, vainly skg., at Kiel.

660. L. albus L.—Delpino states that this species essentially agrees with L. luteus ('Ult. oss.,' pp. 46–7).

661. L. hirsutus L.—

VISITORS.—Schletterer saw the humble-bee Bombus terrester *L.* at Pola.

201. Ononis L.

Generally red, rarely white or yellow, nectarless bee flowers, with a pumping arrangement from which threads of pollen are extruded. Bentham says that apetalous cleistogamous flowers are often present in South European species.

662. O. spinosa L. (Herm. Müller, 'Fertilisation,' pp. 174–5; Kirchner, 'Flora v. Stuttgart,' pp. 478–9; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 57–8; Loew, 'Blütenbiol. Floristik,' p. 392; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The flowers of this species are rose-red in colour, more rarely white, without nectar or nectar-guides. Hermann Müller describes the alae as flat plates, that are separate below but converge above to ensheath the upper part of the carina, with which they interlock by means of a pointed process on either side, that projects forwards and downwards internal to the upper alar margin, and fits into a deep carinal fold. There is also a basal lappet projecting backwards from the upper margin of each ala, and resting upon the sexual column, without touching its fellow.

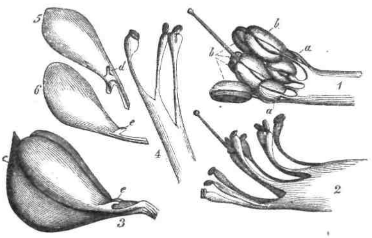


FIG. 88. *Ononis spinosa*, *L.* (after Herm. Müller). (1) Reproductive organs of a bud. (2) The same of a mature flower (× 7). (3) Flower after removal of calyx and vexillum, seen from the side. (4) Some stamens, more highly magnified, to show the difference between the outer and inner filaments as regards thickening. (5) Left ala seen from the inner side, with the upper margin directed downwards. (6) Outer surface of the same. *a* and *b*, outer and inner stamens; *c*, pollen in the tip of the carina, seen by transparency; *d*, pointed alar process; *e*, alar lappet.

The ten cohering filaments are somewhat thickened just below the anthers, the five outer ones much more strongly than the others. The anthers of the five inner stamens, on the other hand, produce a larger quantity of pollen. Before anthesis, the anthers extend to the base of the hollow cone formed by the tip of the carina, completely fill this with pollen, and then shrivel up. The stigma is situated a little below the carinal apex.

The upper margins of the carinal petals are at first united for the whole of their extent, except that a small opening is left at the tip. If now the carina is slightly depressed, the thickened ends of the filaments are pushed further into the pollen-chamber, and a corresponding amount of pollen is squeezed out. The carina returns to its original position when the pressure ceases. With repeated depression the united upper margins of the carinal petals are split apart, when stamens and

style protrude, returning again to the cavity of the carina if the pressure is not too strong. But if this is considerable they remain entirely or partially projecting out of the carina.

Visitors.—These are bees, especially Dasygastres, of which Herm. Müller observed the following in Westphalia.—

1. Anthidium manicatum *L.* ♀ and ♂, freq.; 2. A. punctatum *Ltr.* ♀ and ♂; 3. Megachile circumcincta *K.* ♀, freq.; 4. M. lagopoda *L.* ♀ and ♂, do.; 5. M. versicolor *Sm.* ♀; 6. Osmia aenea *L.* ♀, freq.; and in Thuringia, 7. O. aurulenta *Pz.* ♀, do.

Herm. Müller also saw the following Scopulipedes in Westphalia.—

1. Apis mellifica *L.* ☿; 2. Bombus lapidarius *L.* ☿; 3. B. terrester *L.* ♀; 4. Cilissa leporina *Pz.* ♀; and in Thuringia, 5. Podalirius vulpinus *Pz.* ♀ and ♂, freq.

In Schleswig-Holstein I noticed only the Scopulipedes Apis, Bombus terrester, and B. lapidarius, while Loew saw the dasygastrid Megachile maritima *K.* ♀, po-cltg., in North Germany. In the Berlin Botanic Garden he also observed Anthidium manicatum *L.* ♀, po-cltg., and also skg. persistently in spite of the absence of nectar; when the ♀ was caught a ♂ immediately visited the same flower, obstinately returning after being driven away.

The following have been recorded by the naturalists and at the places mentioned.—

Alfken (Bremen), the bees, 1. Andrena flavipes *Pz.* ♀, 2nd generation; 2. Bombus arenicola *Ths.* ♀; 3. B. distinguendus *Mor.* ♀; 4. Megachile maritima *K.* ♀; all po-cltg. Sickmann (Osnabrück), the fossorial wasp Astata minor *Kohl.* Alfken (Juist), the bees, 1. Bombus lapidarius *L.* ♀; 2. B. muscorum *F.* ☿; 3. B. terrester *L.* ☿; 4. Megachile maritima *K.* ♀ and ♂. Rössler (Wiesbaden), the following Lepidoptera as unbidden guests—1. Grapholitha microgammana *Gn.*; 2. Acidalia humiliata *Hufn.*; 3. Hesperia actaeon *Rott.*; 4. Lycaena argus *L.* MacLeod (Flanders), Apis, 4 humble-bees, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 335–6).

663. O. repens L. (=O. procurrens *Wallr.*). (Herm. Müller, 'Weit. Beob.,' II, p. 254; Kirchner, 'Flora v. Stuttgart,' p. 479; Knuth, 'Bloemenbiol. Bijdragen'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The flower mechanism agrees with that of the last species, except that the blossoms are rather larger (Kirchner). Warnstorf states that the downwardly directed pointed alar process is longer and sharper than in O. spinosa. The pollen-grains are golden yellow in colour, of broad or narrow ellipsoidal shape, about 37 μ long and 25 μ broad.

Visitors.—These are the following bees, po-cltg., or vainly skg.—

A. Dasygastres. 1. Anthidium manicatum *L.* ♀ and ♂ (Buddeberg, Nassau); 2. A. oblongatum *Ltr.* (do.); 3. Megachile argentata *F.* (do.); 4. M. circumcincta *K.* ♀ (do.); 5. M. fasciata *Sm.* ♂, skg. (do.); 6. Osmia spinulosa *K.* ♀ (Herm. Müller, Thuringia). **B. Scopulipedes.** 7. Bombus agrorum *F.* (Knuth, Holstein); 8. B. variabilis *Schmiedekn.*, var. tristis *Seidl.* (Herm. Müller, Thuringia); 9. Cilissa leporina *Pz.* ♀, skg. (Buddeberg, Nassau).

I saw the honey-bee, skg., in Rügen.

H. de Vries observed the humble-bee Bombus terrester *L.* ☿ in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

664. O. arvensis L. (Syst. Nat.)—Kirchner describes the mechanism as agreeing with those of the last two species, though the flowers are often smaller.

Visitors.—In Dumfriesshire, the honey-bee and a humble-bee have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 43).

665. O. Natrix L. (MacLeod, 'Pyreneenbl.'; Kirchner, 'Beiträge,' p. 40.)—The flowers of this species are yellow, with dark red streaks on the vexillum. Kirchner states that the mechanism agrees with those of the last two species.

Visitors.—In the Pyrenees, MacLeod observed three Dasygastres (a Megachile and 2 Osmia), and 6 Scopulipedes (an Andrena, 4 Bombus, and an Eucera).

666. O. rotundifolia L.—According to Briquet ('Études de biol. flor. dans les Alpes occident.'), the rose-red flowers of this species possess a pumping arrangement extruding threads of pollen, as in other species of the genus. Insect visitors, mostly bees and Lepidoptera, are very numerous. They usually effect cross-pollination, for the stigma projects beyond the anthers, and does not become sticky until its papillae have rubbed against an insect's body. Automatic self-pollination can take place at the end of anthesis. The uppermost stamen is not fused with the others. Kirchner, however, found it to be united with its neighbours for about 3 mm. at the base, but otherwise free. He also states that the flowers exhale an odour of roses.

Visitors.—*Vide supra.*

202. Medicago L.

Yellow or bluish nectar-yielding bee flowers, the stamens and pistil of which spring out of the carina.

667. M. sativa L. (Henslow, J. Linn. Soc., Bot., London, ix, 1867; Hildebrand, Bot. Ztg., Leipzig, xxiv, 1866, pp. 74–5, and xxv, 1867, p. 283; Delpino, 'Sugli appar. d. fecondaz. nelle piante autocarp.,' pp. 26–8, 'Ult. oss.,' pp. 47–8; Herm. Müller, 'Fertilisation,' pp. 175–8, 'Weit. Beob.,' II, p. 252; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 336–8; Knuth, 'Bloemenbiol. Bijdragen'; Loew, 'Blütenbiol. Floristik,' p. 391.)—The bluish or violet blossoms are aggregated into tolerably conspicuous many-flowered racemes. Each individual flower is 7 to 11 mm. in length. Nectar is secreted in the usual place, and there is a passage to it on either side of the free stamen, as in similar cases. The pressure exerted by an insect visitor causes stamens and style to spring out of the carina, to which they are unable to return. The elasticity necessary to bring about explosion lies entirely in the upper stamens, and there are two arrangements in the unvisited flower by which this is kept in check.—(1) At the upper basal angle of either carinal petal there is an internal hollow process, forwardly directed, and closely apposed to its fellow, the two together gripping the front part of the sexual column from above. A still more pronounced alar process fits into each of them. (2) From the upper edge of each ala a long fringe-like process runs back, passing upwards and inwards so as to grasp, with its fellow, the upper side of the column at a point about one-third of its length from the base.

The various processes described forcibly maintain the sexual column in a horizontal position. But should an insect visitor press down the alae and carina, the stamens and pistil spring up out of the carina against the under-side of its body or proboscis. The stigma projects beyond the anthers, and therefore first

comes into contact with the insect, getting cross-pollinated if this has previously visited another flower of the species. The first flower visited by an insect will be self-pollinated as the visitor backs out of it. Should insect-visits fail, automatic self-pollination of unexploded flowers is possible, and may be effective under certain conditions (*vide infra*).

Burkill (Proc. Phil. Soc., Cambridge, viii, 1894) aptly describes the basal processes of alae and carina as two triggers, by which the flower is, so to speak, fired off. He states that the upper surfaces of the alae are beset with papillae, serving as foot-holds to insect visitors. There is also a marginal row of papillae on either side of the vexillum's inner surface, to which long-legged insects would appear to cling. The stigma remains unreceptive until its papillae have been subjected to friction. By covering a number of inflorescences with nets, in order to keep away insects, Burkill was able to confirm the conclusion at which Urban had previously arrived (Verh. bot. Ver., Berlin, xv, 1873), i.e. that unexploded flowers do not set fruits, although their stigmas are surrounded by pollen. He succeeded, however, in inducing such flowers to fruit by (1) squeezing the stigma through the tip of the carina, (2) piercing the carina with a needle and scratching the stigma, (3) cutting off the tip of the carina and rubbing the stigma with a paint-brush.

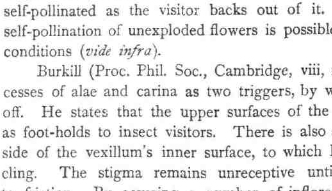


FIG. 89. *Medicago sativa*, *L.* (after Herm. Müller). (1) Unvisited flower, seen from below. (2) The same, after removal of the vexillum and upper half of the calyx; seen from above. (3) Right ala seen from inside. (4) Carina, seen from above and from the right. (5) Exploded flower, seen from above and from the left, after removal of the vexillum and upper half of the calyx (×3½). *a*, calyx; *b*, vexillum; *c*, ala; *d*, alar claw; *e*, anterior alar process; *f*, cavity of this process; *g*, posterior finger-shaped alar process; *h*, carina; *i*, carinal process into which the anterior alar process fits; *k*, the cohering filaments; *l*, the free uppermost filament; *m*, nectar-passages; *n*, anther; *o*, stigma.

VISITORS.—These are bees and Lepidoptera. The slender proboscis of the latter is undoubtedly able to bring about explosion, providing it is thrust down to the nectar from the middle of the flower, while, on the other hand, explosion is not effected by insects that suck laterally, as e.g. the honey-bee, which inserts its proboscis into the base of the flower from the side of the vexillum.

Herm. Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) have observed the following.—

A. Hymenoptera. (*a*) *Apidae*: 1. Apis mellifica *L.* ☿, very freq., skg. (H. M., Kn.); 2. Bombus agrorum *L.* ♀ and ☿, skg. (H. M., Kn.); 3. B. terrester *L.*, do. (Kn.); 4. Cilissa leporina *Pz.* ♂, do. (H. M.); 5. Coelioxys rufescens *Lep.* ♂, do. (Kn.); 6. Colletes sp. ♂, do. (H. M.); 7. Halictus morio *F.* ♀, do. (Budd.); 8. Megachile argentata *F.* ♀ and ♂, do. (H. M., Budd.); 9. M. pyrina *Lep.*, do. (H. M.); 10. M. willughbiella *K.* ♂, do. (H. M.); 11. Osmia aenea *L.* ♀, freq., skg. and po-cltg. (H. M.); 12. O. rufa *L.* ♀, skg. (H. M.); 13. Rhophites canus *Ev.* ♂, do. (H. M.); 14. Xylocopa violacea *L.* ♂, do. (H. M.). (*b*) *Sphegidae*: 15. Bembex rostrata *L.*, skg. (H. M.). **B. Lepidoptera.** (*a*) *Noctuidae*: 16. Plusia gamma *L.* (*b*) *Rho-*

palocera: 17. Colias edusa *L.*, skg. (Budd.); 18. C. hyale *L.* (H. M., Budd.); 19. Hesperia lineola *O.*, skg. (Budd.); 20. H. thaumas *Hufn.* (H. M.); 21. Lycaena argiolus *L.* (H. M.); 22. Pieris brassicae *L.* (H. M.); 23. P. napi *L.* (H. M.); 24. P. rapae *L.* (H. M.); 25. Rhodocera rhamni *L.*, skg. (Budd.); 26. Satyrus hyperanthus *L.* (H. M.); 27. Vanessa urticae *L.* (H. M.).

Rössler observed the butterfly Colias edusa *F.*, at Bremen, while bees were recorded by and for the authors and places named in the following list.—

Loew (Brandenburg), Cilissa leporina *Pz.* ♂, skg. ('Beiträge'); Alfken (Bremen), 1. Anthidium manicatum *L.* ♀ and ♂, 2. Bombus variabilis *Schmiedekn.* ☿, 3. Cilissa leporina *Pz.* ♀ and ♂; Frey-Gessner (canton Valais), Eucera hungarica *Friese* ♀ and ♂; Friese (Baden), Cilissa leporina *Pz.*, occasional; Krieger (Leipzig), Eucera longicornis *L.* ♀; Schenck (Nassau), Cilissa leporina *Pz.*, occasional; Dalla Torre and Schletterer (Tyrol), Bombus pomorum *Pz.* ♂.

Burkill observed the following at Cambridge (Proc. Phil. Soc., Cambridge, viii, 1894).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes viridescens *F.* **B. Diptera.** (*a*) *Muscidae*: 2. Caricea tigrina *F.*; 3. Lucilia sericata *Mg.* (*b*) *Syrphidae*: 4. Eristalis pertinax *Scop.*; 5. Helophilus floreus *L.*; 6. Melithreptus scriptus *L.*; 7. Platycheirus albimanus *F.*; 8. P. manicatus *Mg.*; 9. P. scutatus *Mg.*; 10. Syritta pipiens *L.*; 11. Syrphus balteatus *Deg.*; 12. S. corollae *F.*; 13. S. ribesii *L.* **C. Hymenoptera.** (*a*) *Apidae*: 14. Andrena convexiuscula *K.* ♀; 15. A. extricata *Sm.* ♂; 16. Apis mellifica *L.* ☿, very freq.; 17. Bombus agrorum *F.*; 18. B. hortorum *L.*, common; 19. B. lapidarius *L.*; 20. B. pratorum *L.*; 21. Megachile centuncularis *L.* ♀. (*b*) *Vespidae*: 22. Vespa vulgaris *L.* ♂. **D. Lepidoptera.** (*a*) *Noctuidae*: 23. Agrotis pronuba *L.*; 24. Phasiane clathrata *L.*; 25. Plusia gamma *L.* (*b*) *Rhopalocera*: 26. Lycaena icarus *L.*; 27. Pieris brassicae *L.*, freq.; 28. P. napi *L.*; 29. P. rapae *L.*; 30. Polyommatus phlaeas *L.*; 31. Vanessa urticae *L.*

All the visitors suck nectar, though the flies would seem but seldom to reach it, and can only get pollen from exploded flowers. As Hermann Müller previously noticed, the honey-bee does not explode the flowers, but steals the nectar by thrusting in its proboscis from the side. On a hot summer afternoon Burkill saw Bombus hortorum *L.* in large numbers on the flowers, skg. legitimately, and effecting explosion.

Burkill states that the flowers are not all explosive to the same degree, the hotter the weather the more vigorously they explode. In cold weather they remain unexploded for eight or nine days, and then wither; in hot sunny weather anthesis lasts for three days at most. Explosion is not brought about by the shaking of the wind.

Schulz (Thuringia) and Urban (Berlin) have observed flowers perforated by Apis and humble-bees.

668. M. falcata L. (Herm. Müller, 'Fertilisation,' pp. 179–80, 'Weit. Beob.,' II, p. 252; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 338.)—Hermann Müller states that the mechanism of the yellow flowers of this species entirely agrees with that of M. sativa, but the springing up of the sexual column as the result of pressure from above is facilitated by the loose way in which the alae and carina grasp the upper side of this. It is, however, more difficult for bees to extract nectar

without causing explosion, for the basal parts of the relatively short and broad alae rest on the carina for some little distance.

VISITORS.—These are once more bees and Lepidoptera. As a result of the peculiarity last named, the former always effect explosion, while Lepidoptera, owing to the slender character of their proboscis, can extract nectar from unvisited flowers without exploding them.

Herm. Müller observed the following at Röhmberge, near Mühlberg.—

A. Hymenoptera. *Apidae*: 1. Andrena denticulata *K.* ♀, skg.; 2. A. fulvicrus *K.* ♀, do.; 3. Apis mellifica *L.* ☿, freq., skg.; 4. Bombus agrorum *F.* ♀, skg.; 5. Cilissa leporina *Pz.* ♀ and ♂, skg. and po-cltg.; 6. Halictus quadricinctus *F.* ♀, po-cltg.; 7. Nomada ferruginata *K.* ♀, skg.; 8. N. solidaginis *Pz.* ♀, do.; 9. N. fucata *Pz.* ♀, do.; 10. Osmia aurulenta *Pz.* ♀, freq., skg. and po-cltg.; 11. Rhophites canus *Ev.* ♀ and ♂, skg. **B. Diptera.** (*a*) *Bombyliidae*: 12. Systoechus sulphureus *Mikan*, skg. (*b*) *Syrphidae*: 13. Helophidus trivittatus *F.* **C. Lepidoptera.**

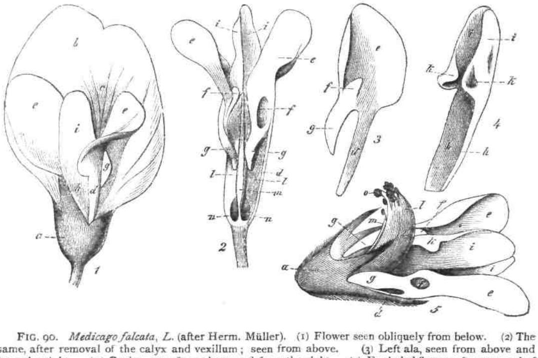


FIG. 90. *Medicago falcata*, *L.* (after Herm. Müller). (1) Flower seen obliquely from below. (2) The same, after removal of the calyx and vexillum; seen from above. (3) Left ala, seen from above and from the right. (4) Carina, seen from above and from the right. (5) Exploded flower, after removal of the vexillum; seen from above and from the right. The sexual column is much foreshortened (×7). *a*, calyx; *b*, vexillum; *c*, nectar-guides; *d*, alar claw; *e*, ala; *f*, anterior alar process; *g*, posterior alar process; *h*, fused claws of carinal petals; *i*, limbs of do.; *k*, carinal pit into which an anterior alar process fits; *l*, sexual column; *m*, upper filament; *n*, nectar-passage; *o*, stigma.

(*a*) *Noctuidae*: 14. Euclidia glyphica *L.*, skg. (*b*) *Rhopalocera*: 15. Epinephele janira *L.*, skg.; 16. Hesperia sylvanus *Esp.*, do.; 17. Lycaena coridon *Poda*, skg.; 18. Melitaea athalia *Rott.*, do.; 19. Pieris rapae *L.*, do.; 20. Vanessa urticae *L.*, do.; (*c*) *Sphingidae*: 21. Sesia asiliformis *Rott.*, skg.; 22. Zygaena carniolica *Scop.*, freq. Herm. Müller also saw a humble-bee and two Lepidoptera in the Alps ('Alpenblumen,' p. 248).

Rössler noticed the butterfly Colias hyale *L.* at Wiesbaden, as an unbidden guest.

Burkill observed the following at Cambridge (Proc. Phil. Soc., Cambridge, viii, 1894).—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.*; 2. Syrphus balteatus *Deg.*; 3. S. luniger *Mg.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Apis mellifica *L.* ☿; 5. Bombus

hortorum *L.* (*b*) *Formicidae*: 6. Formica rufa *L.* (*c*) *Ichneumonidae*: 7. Cryptus analis *Gr.*

Schletterer saw the small leaf-cutting bee Megachile argentata *F.* at Pola.

Schulz (Thuringia) and Urban (Berlin) have observed flowers perforated by Apis and humble-bees.

The flowers are more explosive than those of M. sativa, and Burkill says that they are made more so by warmth. To such an extent is this the case that the pressure exerted by flies (Syrphids, and even Muscids) may be sufficient to liberate the mechanism. When the blossoms are at maximum tension, explosion may be effected by a sudden heavy shower.

669. **M. media** Pers. (= M. falcata × M. sativa). (Knuth, 'Bloemenbiol. Bijdragen.')—The colour of the corolla is variable in this hybrid. At first it is generally yellow, then becomes greenish, and lastly bluish or violet. It grows abundantly on the walls of the fortress at Coburg, where I noticed that some individuals approximated more nearly to M. falcata, and others to M. sativa.

Visitors.—I noticed the honey-bee, common, at Coburg. Loew observed a beetle, and 2 bees in the Berlin Botanic Garden, as follows.—

1. Coccinella octodecimpunctata *Scop.*, settling on the outside of the flower; 2. Andrena fasciata *Wesm.* ♂, skg.; 3. Cilissa tricincta *K.* ♀, po-cltg. and skg. legitimately.

670. **M. prostrata** Jacq. (Burkill, Proc. Phil. Soc., Cambridge, viii, 1894.)—The flower mechanism of this species agrees with that of M. falcata, but the flowers are smaller, and exploded by less pressure on the alae.

671. **M. sylvestris** Fries (=M. falcata, according to Urban, Verh. bot. Ver., Berlin, xv, 1873, p. 56).—According to Burkill (Proc. Phil. Soc., Cambridge, viii, 1894), this species has a closer oecological resemblance to M. sativa than to M. folcata, for its mechanism never attains the highly explosive condition characteristic of the latter.

Visitors.—The honey-bee is by far the commonest visitor in the Cambridge Botanic Garden, sucking the nectar from the side as in M. sativa. As only humble-bees are able to cause explosion, 99 per cent. of the flowers remain unfertilized (at Cambridge).

Visitors.—Burkill observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Caricea tigrina *F.*; 2. Lucilia sericata *Mg.*; 3. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 4. Eristalis pertinax *Scop.*; 5. Melithreptus scriptus *L.*; 6. Platycheirus manicatus *Mg.*; 7. Syritta pipiens *L.*; 8. Syrphus balteatus *Deg.*; 9. S. corollae *F.*; 10. S. luniger *Mg.*; 11. S. ribesii *L.* **B. Hymenoptera.** *Apidae*: 12. Apis mellifica *L.* ☿, very freq.; 13. Bombus hortorum *L.*; 14. B. lucorum *L.*; 15. Odynerus parietum *L.* ♀. **C. Lepidoptera.** *Rhopalocera*: 16. Pieris brassicae *L.*

672. **M. lupulina** L. (Darwin, Gard. Chron., London, 1857; Herm. Müller, Fertilisation,' p. 180, 'Weit. Beob.,' II, p. 252; Kirchner, 'Flora v. Stuttgart,' p. 483; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 59, 152.)—The mechanism of the small (scarcely 2 mm. in length) golden-yellow flowers of this species agrees with that of M. sativa, but the elasticity of the upper stamens is slight. An insect-visit causes the column of reproductive organs to spring out of the carina, to which

it does not return when the pressure is removed. According to Darwin, automatic self-pollination readily takes place, but is far less productive than cross-pollination.

VISITORS.—Darwin in England, MacLeod in Flanders, Hermann Müller in Westphalia, and myself in Schleswig-Holstein have observed the honey-bee. Hermann Müller remarks in this connexion:—'It is characteristic of the honey-bee that it does not disdain even this flower's tiny store of honey. The whole inflorescence is pulled down by the weight of the bee, which then sucks the flower's head downwards. It visits a few flowers, at most four, on one inflorescence, and then flies away to another plant of the same species. Xenogamy is thus effected to a great extent.'

While as a rule the honey-bee has been observed as the chief pollinator, Burkill (Proc. Phil. Soc., Cambridge, viii, 1894, names a hover-fly (*Platycheirus manicatus*) as the most active visitor at Scarborough, a short-tongued bee (*Halictus morio*) and a Muscid (*Scatophaga*) at Cambridge. He gives the following list for Scarborough (June, 1893) and Cambridge (July and August, 1893).—

A. Coleoptera. 1. Anthobium torquatum *Marsh.*; 2. Ceutorhynchidius floralis *Payk.*; 3. Meligethes aeneus *F.* **B. Diptera.** (*a*) *Anthomyidae*: 4. Anthomyia sp.; 5. Caricea tigrina *F.*; 6. Chortophila cinerella *Fall.*; 7. C. sepitorum *Meade*; 8. C. sp.; 9. Homalomyia armata *Mg.*; 10. Hydrotea irritans *Fall.*; 11. Hylemyia pullula *Zett.*; 12. Pogonomyia alpicola *Rnd.*? (*b*) *Bibionidae*: 13. Scatopse brevicornis *Mg.* (*c*) *Chironomidae*: 14. Chironomus sp. (*d*) *Chloropidae*: 15, 16, 17. Three sp. of Chlorops; 18. Oscinis sp.?, very freq. (*e*) *Empidae*: 19. Empis punctata *F.* (*f*) *Muscidae*: 20, 21. Two undetermined sp. (*g*) *Sarcophagidae*: 22. Sarcophaga sp., very freq. (*h*) *Scatophagidae*: 23. Scatophaga stercoraria *L.* (*i*) *Sepsidae*: 24. Hydrellia griseola *Fall.*; 25. Sepsis cynipsea *L.* (*k*) *Syrphidae*: 26. Paragus tibialis *Fall.*; 27. Pipizella virens *F.*; 28. Platycheirus albimanus *F.*; 29. P. manicatus *Mg.*; 30. P. scutatus *Mg.*; 31. Syrphus balteatus *Deg.*; 32. S. corollae *F.*; 33. Syritta pipiens *L.* (*l*) *Tabanidae*: 34. Ptiolina crassicornis *Pz.* (*m*) *Pachinidae*: 35. Myobia inanis *Fall.*; 36. Siphona cristata *F.*; 37. S. geniculata *Deg.* **C. Hemiptera.** 38. Aphis sp.; 39. Siphonophora artemisiae *Koch.* **D. Hymenoptera.** *Apidae*: 40. Andrena parvula *K.* ♀; 41. Apis mellifica *L.* ☿, rare; 42. Bombus hortorum *L.*; 43. Halictus minutissimus *K.* ♂; 44. H. morio *F.* ♂ and ♀, not infrequent; 45–50. Six undetermined species. **E. Lepidoptera.** (*a*) *Noctuidae*: 51. Hadena fasciuncula *Haw.* (*b*) *Pyralidae*: 52. Crambus pratellus *L.* (*c*) *Tineidae*: 53. Porrectaria sp. (*d*) *Tortricidae*: 54, 55. Sp. of Tortrix? **F. Neuroptera.** 56. Thrips sp.

Sickmann mentions the fossorial wasp Gorytes lunatus *Dahlb.*, infrequent.

Besides the honey-bee, Herm. Müller observed the following.—

A. Hymenoptera. *Apidae*: 1. Andrena convexiuscula *K.* ♀, skg.; 2. A. xanthura *K.* ♀, po-cltg.; 3. Bombus agrorum *F.* ♀ and ☿, skg. (Strassburg); 4. Halictus flavipes *F.* ♀, po-cltg. **B. Diptera.** *Conopidae*: 5. Myopa buccata *L.*, skg.; 6. M. testacea *L.*, do. **C. Lepidoptera.** *Rhopalocera*: 7. Thecla rubi *L.* ♀, skg.

Müller further records three Lepidoptera, skg., for the Alps ('Alpenblumen,' p. 248).

MacLeod, in addition to Apis, observed Halictus sp. in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 338). H. de Vries observed Bombus terrester *L.* ☿ in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

673. M. arabica All.—Kirchner ('Flora v. Stuttgart,' p. 484) states that the flower mechanism of this South European species agrees with that of M. sativa.

The flowers are yellow and about 6 mm. long; the vexillum is streaked, the carina is about 4 mm. long, and the alae somewhat shorter.

674. M. hispida Gaertn.—The flowers of this species, which is indigenous to South Europe, are about as long again as those of M. lupulina, according to Kirchner ('Flora v. Stuttgart,' p. 483). Their mechanism is similar.

675. M. carstiensis Jacq.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Bombus rajellus *K.* ☿, skg.; 2. Cilissa tricincta *K.* ♀, skg. legitimately and po-cltg., ♂ skg.; 3. Megachile centuncularis *L.* ♂, skg.; 4. M. circumcincta *K.* ♀, po-cltg.; 5. M. lagopoda *L.* ♀, do.

203. Dorycnium L.

676. D. hirsutum Ser. (=Bonjeania hirsuta *Reichb.*).—In the flowers of this species there is a pumping arrangement, the ends of the filaments being thickened (Delpino, 'Ult. oss.,' p. 45).

VISITORS.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena convexiuscula *K.*, var. fuscata *K.*; 2. A. morio *Brull.*; 3. Bombus argillaceus *Scop.*; 4. B. terrester *L.*; 5. Eucera hispana *Lep.*; 6. E. interrupta *Baer*; 7. Megachile muraria *L.*; 8. Podalirius retusus *L.*, var. meridionalis *Pér.* (*b*) *Sphegidae*: 9. Cerceris specularis *Costa.*

677. D. herbaceum Vill.—

VISITORS.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Anthidium strigatum *Ltr.*; 2. Andrena dubitata *Schenck*; 3. A. limbata *Ev.*; 4. A. morio *Brull.*; 5. Coelioxys aurolimbata *Först.*; 6. Colletes lacunatus *Dours.*; 7. Eucera alternans *Brull.*; 8. E. clypeata *Er.*; 9. E. interrupta *Baer.*; 10. E. ruficollis *Brull.*; 11. Halictus calceatus *Scop.*, var. obovatus *K.*; 12. H. maculatus *Sm.*, one ♂; 13. H. morbillosus *Kriecht.*; 14. H. quadricinctus *F.*; 15. H. scabiosae *Rossi*; 16. H. villosulus *K.*; 17. Nomada nobilis *H. Sch.*; 18. N. ochrostoma *K.*; 19. Nomia diversipes *Ltr.*; 20. Osmia andrenoides *Spin.*; 21. O. crenulata *Mor.*; 22. Prosopis clypearis *Schenck*; 23. P. variegata *F.*; 24. Sphecodes gibbus *L.*; 25. S. subquadratus *Sm.*; 26. Xylocopa cyanescens *Brull.*, one ♀. (*b*) *Braconidae*: 27. Bracon terrefactor *Vill.* (*c*) *Chalcididae*: 28. Leucaspis dorsigera *F.*; 29. L. gigas *F.*; 30. L. intermedia *Ill.* (*d*) *Evaniidae*: 31. Gasteruption pedemontanus *Tourn.*; 32. G. rubicans *Gnér.*; 33. G. tibiale *Schlett.* (*e*) *Pompiliidae*: 34. Agenia erythropus *Kohl.*; 35. Pompilus quadripunctatus *F.*; 36. Pseudagenia carbonaria *Scop.* (*f*) *Scoliidae*: 37. Myzine tripunctata *Rossi*; 38. Scolia hirta *Schr.*; 39. S. insubrica *Scop.*; 40. S. quadripunctata *F.*; 41. Tiphia minuta *v. d. L.* (*g*) *Sphegidae*: 42. Cerceris arenaria *L.*; 43. C. bupresticida *Duf.*; 44. C. emarginata *Pz.*; 45. C. ferreri *v. d. L.*; 46. C. labiata *F.*; 47. C. leucozonica *Schlett.*; 48. C. quadrimaculata *Duf.*; 49. C. rybiensis *L.*; 50. C. specularis *Costa*; 51. Gorytes quinquecinctus *F.*; 52. Oxybelus melancholicus *Chevr.*; 53. Tachytes europaeus *Kohl.*; 54. T. obsoletus *Rossi.* (*h*) *Tenthredinidae*: 55. Cyphona furcata *Vill.*, var. melanocephala *Pz.* (*i*) *Vespidae*: 56. Eumenes pomiformis *F.*; 57. Polistes gallica *L.*

204. Indigofera L.

(Hildebrand, Bot. Ztg., Leipzig, xxiv, 1866, pp. 74–5.)

Flowers with explosive mechanism. Carina and alae fold downwards when the tension is released, so that the column of stamens and pistil remains horizontal. Automatic self-pollination is possible when the flowers fade.

678. I. speciosa.—This species, according to Henslow (J. Linn. Soc., Bot., London, ix, 1867), possesses the flower mechanism described by Hildebrand (*vide supra*), and represents it as expressly adapted to secure cross-pollination.

679. I. macrostachya Vent.—

VISITORS.—Delpino saw Bombus italicus ('Ult. Oss.,' p. 54).

205. Parochetus Buch.-Ham.

Kuhn states that cleistogamous flowers occur in this genus.

206. Melilotus Tourn.

Yellow or white bee flowers, arranged in racemes. They secrete nectar and smell like cumarin. There is a simple valvular arrangement by which the stamens and pistil are caused to protrude from the carina so long as pressure is exerted by visitors (bees).

680. M. altissima Thuill. (=M. officinalis *Willd.*). (Herm. Müller, 'Fertilisation,' pp. 180–1; Kerner, 'Nat. Hist. Pl.,' Eng. ed. 1, II; Schulz, 'Beiträge,' II, p. 208; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 338–9; Loew, 'Blütenbiol. Floristik,' pp. 392, 395; Knuth, 'Bloemenbiol. Bijdragen.')—The bright golden-yellow flowers of this species exhale an odour of cumarin. Hermann Müller states that the calyx is only 2 mm. long, and moderately wide, so that the nectar can be reached by short-tongued insects. The alae and the carina are partially fused together on either side, so that both are depressed when the flower is visited by an insect, and simultaneously return to their original position when the pressure is removed. The latter movement is due to the fact that there are two finger-like processes directed backwards and inwards on the upper basal angle of the alae, and embracing the column formed by the stamens and pistil. These processes slide along the upper side of the column during depression, returning to their original position when the pressure is removed, and guiding the carina and alae back to theirs.

As the stigma projects beyond the anthers, cross-pollination is secured by insect-visits; failing these, automatic self-pollination is difficult, but Kerner states that it is effective.

VISITORS.—Herm. Müller observed the following.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena dorsata *K.* ♀, skg. and po-dvg.; 2. Apis mellifica *L.* ☿, very freq., do.; 3. Coelioxys quadridentata *L.* ♂, skg.; 4. Heriades truncorum *L.* ♀, po-cltg.; 5. Osmia sp. (*b*) *Sphegidae*: 6. Ammophila sabulosa *L.* ♂, skg. (*c*) *Tenthredinidae*: 7. Tenthredo sp., vainly searching for nectar.

In Schleswig-Holstein I saw only the honey-bee, in great numbers, po-cltg. and skg.

Loew observed a short-tongued bee (Halictus zonulus *Sm.* ♀) po-cltg. in Central Germany, and the following at Warnemünde.—

A. Hymenoptera. (*a*) *Apidae*: 1. Andrena pilipes *F.* ♀, po-cltg.; 2. Anthidium strigatum *Ltr.* ♀, do.; 3. Coelioxys quadridentata *L.* ♂, skg.; 4. C. elongata *Lep.* ♀, do.; 5. C. rufocaudata *Sm.* ♂, do.; 6. Halictus rubicundus *Chr.* ♀, po-cltg.; 7. Osmia

claviventris *Thoms.* ♂, skg. (*b*) *Sphegidae*: 8. Oxybelus furcatus *Lep.*, skg. **B. Diptera.** *Empidae*: 9. Empis sp.

Schletterer records the following for Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Anthidium strigatum *Ltr.*; 2. Andrena convexiuscula *K.*; 3. A. flessae *Pz.*; 4. A. limbata *Ev.*; 5. A. lucens *Imh.*; 6. A. morio *Brull.*; 7. A. nana *K.*; 8. A. thoracica *F.*; 9. Halictus calceatus *Scop.*; 10. H. morbillosus *Krchb.*; 11. H. patellatus *Mor.*; 12. H. sexcinctus *F.*; 13. H. tetrazonius *Klg.*; 14. Nomia diversipes *Ltr.* (*b*) *Tenthredinidae*: 15. Amasis laeta *F.*; 16. Cephus haemorrhoidalis *F.*; 17. C. pygmaeus *L.* (*c*) *Vespidae*: 18. Polistes gallica *L.*

Schulz saw bees perforating the flowers.

681. M. officinalis Desr. (= M. arvensis *Wallr.*). (Knuth, 'Bloemenbiol. Bijdragen.')—The golden-yellow flowers of this species also smell like cumarin, and possess the same mechanism as those of M. altissima.

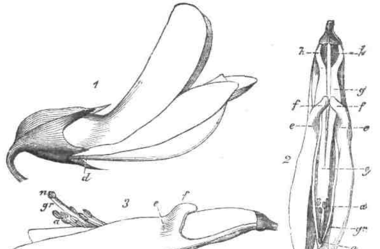


FIG. 91. *Melilotus officinalis*, *Willd.* (after Herm. Müller). (1) Flower seen from the side. (2) The same, after removal of the vexillum and calyx; seen from above. (3) The same, after the alae and carina have been pressed down; seen from the side. *a*, anthers; *d*, pivot on which the carina turns; *e*, depressed parts of the alae, the inner surfaces of which are united with the outer surfaces of the two carinal petals, by the fusion of superficial cells; *f*, finger-like processes of the superior basal angles of the alae; *g*, column of stamens and pistil; *h*, nectar-passage; *gr*, style; *n*, stigma.

VISITORS.—I have seen the honey-bee.

Loew observed the following in Mecklenburg ('Beiträge,' p. 45).—

A. Diptera. *Empidae*: 1. Empis sp. **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena pilipes *F.* ♀, po-cltg.; 3. Anthidium strigatum *Ltr.* ♀, do.; 4. Coelioxys conica *L.* ♂, skg.; 5. C. elongata *Lep.* ♀, do.; 6. C. octodentata *Lep.* ♂, do.; 7. Halictus rubicundus *Chr.* ♀, po-cltg.; 8. Osmia claviventris *Thoms.* ♂, skg. (*b*) *Sphegidae*: 9. Oxybelus furcatus *Lep.*, skg.

Schletterer and Dalla Torre record the following bees for the Tyrol.—

1. Bombus hortorum *L.*; 2. B. mastrucatus *Gerst.*; 3. Ceratina cyanea *K.*

682. M. alba Desr. (=M. vulgaris *Willd.*). (Herm. Müller, 'Fertilisation,' p. 181, 'Weit. Beob.,' II, p. 252; Loew, 'Blütenbiol. Floristik,' p. 392; Kirchner, 'Beiträge,' p. 40; Knuth, 'Bloemenbiol. Bijdragen.')—The white flowers of this species, which also smell of cumarin, possess the same mechanism as those of M. officinalis. The calyx is 2 mm. long; the blade of the oblique vexillum is 4 mm. in length; the carina and alae project for $2\frac{1}{2}$ mm. from the calyx. The anthers mature shortly before anthesis, and do not reach the level of the stigma.

VISITORS.—Besides the honey-bee (po-cltg. and nect-skg.) numerous other insects have been observed. Loew saw the following at Warnemünde.—

A. Hymenoptera. (*a*) *Apidae*: 1. Andrena cineraria *L.* ♀, po-cltg.; 2. A. fulvicrus *K.* ♀, do.; 3. A. gwynana *K.*, var. aestiva *Sm.* ♀, do.; 4. A. pilipes *F.* ♀, do.; 5. Coelioxys conica *L.* ♀, skg.; 6. C. elongata *Lep.* ♂, do.; 7. C. sp., do.; 8. Colletes fodiens *K.* ♂, do.; 9. Macropis labiata *Pz.* ♀, do. (*b*) *Sphegidae*: 10. Cerceris arenaria *L.* ♀ and ♂, skg. (*c*) *Vespidae*: 11. Odynerus parietum *L.*, var. renimacula *Lep.*, skg.; 12. Eumenes coarctata *L.*, do. **B. Diptera.** (*a*) *Chironomidae*: 13. Ceratopogon fasciatus *Mg.* ♀. (*b*) *Conopidae*: 14. Physocephala rufipes *F.*, skg. (*c*) *Muscidae*: 15. Olivieria lateralis *F.* (*d*) *Syrphidae*: 16. Eristalis intricarius *L.*, skg.; 17. Helophilus pendulus *L.*, do.; 18. Melithreptus sp.; 19. Volucella bombylans *L.*, do.

Friese, quoting Konow and Sajo respectively, gives Systropha curvicornis *Scop.*, not infrequent, for Mecklenburg, and Osmia grandis *Mor.* (a ♂) for Hungary.

Alfken observed the following bees at Bremen.—

1. Andrena flavipes *Pz.* ♀; 2. A. propinqua *Schenck* ♀; 3. Bombus lapidarius *L.* ☿.

Ducke saw the following bees at Aquileja.—

1. Eucera (Macrocera) ruficornis *F.* ♂; 2. E. (M.) salicariae *Lep.* ♀.

Schletterer and von Dalla Torre noticed the bee Halictus rubicundus *Chr.* ♂, in the Tyrol.

Schmiedeknecht mentions Andrena nasuta *Gir.* as a rare visitor.

Schulz observed flowers perforated by bees.

683. M. dentata Pers.—

VISITORS.—In this species also Schulz observed flowers perforated by bees.

684. M. caerulea Desr. (=Trigonella caerulea *Ser.*). (Kirchner, 'Beiträge,' p. 41.)—The bright blue flowers of this plant, which are arranged in short crowded racemes, possess a mechanism agreeing with those of the other species of Melilotus; but the stigma is either surrounded by the anthers or projects but little beyond them. The calyx is 3–4 mm., the limb of the vexillum 5 mm., the alae 3 mm., and the carina 2 mm. in length. Each ala possesses a basal process overlapping the staminal tube, so that the alae and carina can only be depressed by the application of considerable force. The stamens and pistil then spring up towards the vexillum, but return again into the carina when the pressure is removed.

VISITORS.—Kirchner observed the honey-bee.

207. Trifolium Tourn.

Yellow, white, or red bee flowers (very rarely Lepidopterid flowers as well) arranged in heads; nectar-secreting and odorous. There is a simple valvular arrangement as in the last genus. According to Kuhn (Bot. Ztg., Leipzig, xxv, 1867), some species bear cleistogamous flowers; Darwin states that this is the case in T. polymorphum ('Forms of flowers').

685. T. repens L. (Herm. Müller, 'Fertilisation,' pp. 181–3, 'Weit. Beob.,' II, p. 246; Darwin, Ann. Mag. Nat. Hist., London, Ser. 3, ii, 1858, p. 460; Lindmann, 'Bidrag till Känned. om Skand. Fjällväxt. Blomn. o. Befrukt.'; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 342–9; Loew, 'Blütenbiol. Floristik,' p. 395; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 59–60, 153, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 232, 'Bl. u. Insekt. a. d. Halligen,' 'Bl. u. Insekt. a. Helgoland,' 'Bloemenbiol. Bijdragen,'

'Blütenbiol. Beob. in Thüringen,' 'Blütenbiol. Beob. a. d. Ins. Rügen,' &c.)—The white or reddish flowers of this species smell like honey. The nectar is secreted as usual, i. e. on the inner side of the base of the staminal tube. The calyx-tube is only 3 mm. long, so that even short-tongued bees are able to reach the nectar. Hermann Müller states that the alae are partly fused with the carina on either side, so that both move simultaneously upwards and downwards. Their depression by the weight of a nectar-seeking insect is facilitated by the fact that the claws are very slender. These claws are fused for the most part with the staminal tube, which is cleft above. The return of the parts to their original position is chiefly due to the action of the vexillum and alae. The broad claw of the former grasps the other petals, as well as the stamens and pistil, and, owing to its elasticity, guides their bases back to the original position when the pressure is removed. The front parts of the petals, and the reproductive column, return to their places because the dorso-basal processes of the alae are converted into two elastic swellings lying close together above the staminal tube.

In order to reach the nectar, an insect visitor must thrust its head beneath the vexillum, and in doing so has only the alae for a support. These and the carina are consequently pressed downwards, and the vexillum upwards, while stamens and stigma protrude from the carina. As the stigma projects somewhat beyond the anthers, cross-pollination is greatly favoured. Bees alone are able to work the flower mechanism properly, so as regularly to effect cross-pollination; other visitors, e. g. Diptera and Lepidoptera, only do this occasionally.

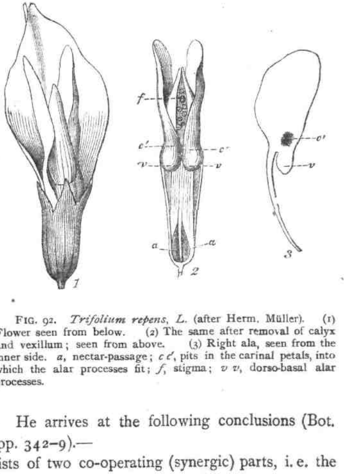


FIG. 92. *Trifolium repens, L.* (after Herm. Müller). (1) Flower seen from below. (2) The same after removal of calyx and vexillum; seen from above. (3) Right ala, seen from the inner side. *a*, nectar-passage; *c c'*, pits in the carinal petals, into which the alar processes fit; *f*, stigma; *v v*, dorso-basal alar processes.

MacLeod gives a detailed account of the flower mechanism, which deviates in some respects from Müller's description. He arrives at the following conclusions (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 342–9).—

The flower of T. repens consists of two co-operating (synergic) parts, i. e. the alae and carina, which are united together, and move simultaneously in the same direction. Each of these parts, however, may execute independent movements. In this connexion two other organs have to be considered, the filaments (which are passive) and the claw of the vexillum (which seems to play an active part). When the alae and the carina of an unvisited flower are pressed down from 30 to 40 times in succession, the mechanism does not appear to be exhausted: the reproductive organs always return into the carina after the pressure has been removed. If,

however, pressure is exerted on the carina alone or the alae alone several times in succession, these parts resume their original position again, but slowly, and the mechanism gives distinct indications of exhaustion. By the union of various co-operating (synergic) organs, Nature has not only afforded greater certainty of movement, but has even been able to minimize exhaustion.

The movements of the higher animals are similarly rendered effective by the *grouping of co-ordinated muscles*: in this way the same advantages are obtained as by the co-operation of alae, carina, and vexillum in the flower of Trifolium repens.

According to Darwin's experiments ('Cross- and Self-fertlsn.,' p. 361) cross-pollination is necessary for the complete fertility of white clover; when insects are excluded the flowers are to a great extent self-sterile.

VISITORS.—Hermann Müller in Westphalia (H. M.), Buddeberg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein (S.-H.), Rügen (R.), Helgoland (H.), and Thuringia (T.) have observed the following.—

A. Diptera. (*a*) *Conopidae*: 1. Myopa buccata *L.*, skg. (H. M.); 2. M. testacea *L.*, do. (H. M.). (*b*) *Syrphidae*: 3. Eristalis sp. (H. M.); 4. Volucella bombylans *L.*, skg. (H. M.). **B. Hymenoptera.** *Apidae*: 5. Andrena fulvicrus *K.* ♀, skg. (H. M.); 6. A. nigriceps *K.* ♀, do. (H. M.); 7. A. sp. (Kn., H.); 8. Anthophora quadrimaculata *Pz.* ♀ (Kn., S.-H. and H.); 9. Apis mellifica *L.* ☿, very freq., skg., and po-cltg. (H. M.; Kn., S.-H. and R.); 10. Bombus cognatus Steph. ☿ and ♀ (Kn., S.-H.); 11. B. derhamellus *K.* (Kn., S.-H.); 12. B. lapidarius *L.* ☿ and ♀ (Kn., S.-H. and T.); 13. B. pratorum *L.* ☿, skg. (H. M.); 14. B. rajellus *K.* ♀, do. (Kn., R.); 15. B. terrester *L.* (Kn., T.); 16. Cilissa leporina *Ps.* ♂, skg. (Budd.); 17. Colletes balteatus *Nyl.* (Kn., S.-H.); 18. Eucera difficilis (Duf.) *Pér.* (Kn., R.); 19. Halictus maculatus *Sm.* ♀, po-cltg. (H. M.); 20. H. sexnotatus *K.* ♀, skg. (H.M.); 21. H. smeathmanellus *K.* ♀, do. (Budd.); 22. H. tarsatus *Schenck* ♀, do. (H. M.); 23. H. zonulus *Sm.* ♀, do. (H. M.); 24. Megachile willughbiella *K.* ♂ (H. M.); 25. Psithyrus quadricolor *Lep.* ♂, skg. (H. M.). **C. Lepidoptera.** *Rhopalocera*: 26. Coenonympha pamphilus *L.*, skg. (H. M., T.); 27. Epinephele janira *L.*, skg. (Kn., S.-H.); 28. Hesperia, do. (H. M.); 29. Melitaea athalia *Esp.*, do. (H. M., T.); 30. Lycaena semiargus *Rott.*, do. (Kn., S.-H.); 31. Pieris brassicae *L.*, do. (H. M.; Kn., S.-H.); 32. P. napi *L.*, do. (H. M.).

Herm. Müller also noticed 11 bees, a hover-fly, and 10 Lepidoptera in the Alps ('Alpenblumen,' p. 244).

Von Dalla Torre saw the bee Stelis aterrima *Pz.* ♀ in the Tyrol.

Hoffer records the rare Alpine humble-bee Bombus alpinus *L.*, an old nest-female, for Steiermark. Loew observed Halictus zonulus *Sm.* ♀, po-cltg. in the same province ('Beiträge,' p. 53), and the honey-bee in Silesia (op. cit., p. 34).

Schiner saw the Muscid Ocyptera pusilla *Mg.* (probably vainly endeavouring to suck) in Austria. Rössler noticed the butterfly Colias hyale *L.* as a useless visitor at Wiesbaden. Schenck records the bee Melitta leporina *Pz.* for Nassau.

Schletterer mentions the following bees for the Tyrol (T.) and Pola.—

1. Andrena dubita *Schenck*; 2. Megachile muraria *L.*; 3. Osmia tridentata *Duf. et Perr.*; 4. Stelis aterrima *Pz.* (T.).

Friese, on the authority of Konow, gives the two following rare bees for Mecklenburg.—

1. Colletes nasutus *Sm.*; 2. Meliturgus clavicornis *Ltr.*

Alfken and Höppner (H.) observed the following bees at Bremen.—

1. Andrena flavipes *Pz.* ♀ (2nd generation); 2. Bombus agrorum *F.* ☿; 3. B. arenicola *Ths.* ☿; 4. B. derhamellus *K.* ♀, ☿, and ♂; 5. B. distinguendus *Mor.* ☿ skg., ♀ (H.); 6. B. hortorum *L.* ☿, skg. and po-cltg. ♀; 7. B. lapidarius *L.* ☿; 8. B. lucorum *L.* ☿; 9. B. muscorum *F.* ☿; 10. B. sylvarum *L.* ☿; 11. B. terrester *L.* ☿; 12. Coelioxys rufescens *Lep.* ♀ and ♂; 13. Melitta leporina *Pz.* ♀ and ♂; 14. Psithyrus barbutellus *K.* ♂.

Verhoeff saw the following in Norderney.—

A. Diptera. (*a*) *Syrphidae*: 1. Syrphus corollae *F.* ♀, not infrequent; 2. S. pyrastri *L.*, occasional. **B. Hymenoptera.** (*a*) *Apidae*: 3. Bombus hortorum *L.* ☿; 4. B. lapidarius *L.* ♀ ☿ and ♂, freq., skg.; 5. B. terrester *L.* ☿, freq. **C. Lepidoptera.** (*a*) *Noctuidae*: 6. Plusia gamma *L.*

Alfken noticed the following bees in Juist.—

1. Bombus distinguendus *Mor.* ☿ po-cltg. and skg.; 2. B. hortorum *L.* ☿, do.; 3. B. lapidarius *L.* ☿, do.; 4. B. muscorum *F.* ☿, do.

MacLeod observed Apis, a humble-bee, a fossorial wasp, and 7 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 349); and 8 humble-bees, 2 short-tongued bees, a lepidopterid, and a beetle in the Pyrenees (op. cit., iii, 1891, p. 436). H. de Vries saw the honey-bee in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

E. D. Marquard noticed the bee Melitta leporina *Pz.* in Cornwall.

In England Smith saw the bee Melitta leporina *Pz.* and Saunders the bee Colletes marginatus *L.*

In Dumfriesshire Apis and a hover-fly have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 46).

Schneider gives the following bees for Arctic Norway (Tromsø. Mus. Aarsh., xvii, 1895).

1. Bombus lapponicus *L.* ☿ and ♂; 2. B. pratorum *L.* ☿ and ♂; 3. B. scrimshiranus *K.* ☿ and ♂; 4. B. terrester *L.* ☿ and ♂; 5. Psithyrus quadricolor *Lep.* ♂; 6. P. vestalis *Fourcr.* ♂.

Lindman noticed numerous humble-bees in the Dovrefjeld.

Loew saw the honey-bee on the variety *atropurpureum* in the Berlin Botanic Garden.

686. T. hybridum L.—The flowers of this species being at first white and erect, afterwards rose-red and curved downwards, the heads present a white centre and a rose-red margin, and are thus rendered more conspicuous. The mechanism agrees with that of the last species.

Visitors.—Buddeberg saw a bee, Melitta leporina *Pz.* ♂, skg., in Nassau.

I observed the honey-bee and the two following humble-bees in Thuringia ('Bloemenbiol. Bijdragen').—1. Bombus agrorum *F.* ♂ (Coburg, July 4, 1894); 2. B. terrester *L.* ☿ (Inselsberg, July 16, 1894).

687. T. fragiferum L. (Herm. Müller, 'Fertilisation, p. 183, 'Weit. Beob.,' p. 246; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 349; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins., pp. 60, 153, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' 'Bl. u. Insekt. a. d. Halligen.')—As Hermann Müller states, the mechanism in this species is the same as in **T.** repens, but all the parts of the flowers are smaller.

Visitors.—In Kiel I observed the following nect-skg. bees.—

1. Apis mellifica *L.* ☿ (and in Sylt); 2. Bombus lapidarius *L.* ☿; 3. B. sylvarum *L.* ☿. In the island Langeness (the Halligen), so far as I was able to observe, the only pollinator is Anthophora quadrimaculata *Pz.* ♀.

In Westphalia Hermann Müller only noticed the honey-bee, passing from T. fragiferum to T. repens, and vice versa.

Alfken saw the humble-bee Bombus terrester *L.* ☿ in Juist; also at Bremen, freq., skg. and po-cltg. Even when covered by his collecting-net it continued quietly to collect pollen.

Heinsius observed two bees in Holland.—

1. Apis mellifica *L.* ☿; 2. Bombus lapidarius *L.* ♂ and ☿.

MacLeod records Bombus lapidarius *L.* ☿ for Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 346), and Schiner the Muscid Ocyptera pusilla *Mg.*, vainly trying to suck, for Austria.

688. T. montanum L. (Herm. Müller, 'Fertilisation,' p. 181, 'Weit. Beob.,' II, pp. 250–2, 'Alpenblumen,' p. 143.)—The white flowers of this species, according to Hermann Müller, are about 5 mm. in length from the base to the tip of the carina, while the calyx is 2–3 mm. long. The nectar is therefore accessible to all insects with a proboscis 5 mm. in length. Bees visiting the flowers cause the reproductive organs to protrude as in T. repens. Lepidoptera also effect cross-pollination, for they touch the stigma and stamens as they push their proboscis along the groove of the folded vexillum into the dorsal cleft of the carina. The plant is therefore adapted to cross-pollination by both bees and Lepidoptera. The mechanism agrees in other respects with that of T. repens, except that the rounded alar processes are more feebly developed.

Visitors.—Hermann Müller observed the honey-bee in Westphalia, and the following insects in Thuringia.—

A. Hymenoptera. (*a*) *Apidae*: 1. Apis mellifica *L.* ☿, very freq., skg.; 2. Bombus pratorum *L.* ♂, skg.; 3. Nomada roberjeotiana *Pz.* ♀, do.; 4. N. ruficornis *L.* ♀, do. (*b*) *Sphegidae*: 5. Ammophila campestris *Ltr.* ♀ and ♂, skg. **B. Lepidoptera.** *Rhopalocera*: 6. Hesperia sylvanus *Esp.*, skg.; 7. Lycaena aegon *W. V.* ♀, do.; 8. L. corydon *Poda*, do.; 9. Melitaea athalia *Esp.*, freq., skg. persistently.

Müller saw 8 bees and 8 Lepidoptera in the Alps. Dalla Torre and Schletterer noticed Bombus mastrucatus *Gerst.* ♂ in the Tyrol; and MacLeod records a humble-bee and an Andrena for the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 436–7.

689. T. pratense L. (Darwin, 'Origin of Species,' Chap. III; Herm. Müller, 'Fertilisation,' pp. 184–6, 'Weit. Beob.,' II, pp. 246–7; Lindman, 'Bidrag till Känned. om Skand. Fjällväxt. Blomn. o. Befrukt.'; Loew, 'Blütenbiol. Floristik,' p. 396; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 339–42; Schulz, 'Beiträge,' II, p. 208; Kerner, 'Nat. Hist. Pl.,' Eng. ed. 1, II; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 59, 152–3,' 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 232, 'Bl. u. Insekt. a. d. Halligen,' 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bl. u. Insekt. a. Helgoland,' 'Blütenbiol. Beob. in Thüringen,' 'Bloemenbiol. Bijdragen.')—The red, rarely white, flowers of this species, which smell like honey, are aggregated into conspicuous spherical heads, abundantly visited by insects. Herm. Müller

states that the nectar is concealed in the base of a tube 9–10 mm. long, formed by fusion of the nine lower filaments with the claws of the petals. The upper free stamen lies on one side of the flower, so that the whole of the cleft in the staminal tube serves as a nectar passage. When a bee thrusts its proboscis under the vexillum towards the nectar, it holds on with its fore-legs to the alae, which are united with the carina, while its other two pairs of legs are supported by deeper parts of the capitulum. The pressure exerted depresses the carina and alae, so that the stigma protrudes, to be immediately followed by the upwardly dehisced anthers, which press against the under-side of the bee's head. The stigma consequently receives pollen brought from another flower, and this is replaced by a fresh supply. Cross-pollination is thus assured. Self-pollination may also take place when the head of the bee is withdrawn, but Darwin says that this is ineffective (though Kerner is of the opposite opinion), and is rendered inoperative by the previously effected cross-pollination.

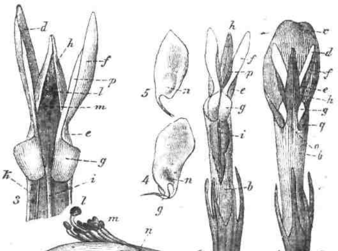


FIG. 93. *Trifolium pratense, L.* (after Herm. Müller). (1) Flower seen from below. (2) The same, after removal of *the vexillum; seen from above. (3) Anterior part of the same* with the edges of the carina pressed apart (enlarged to twice the scale of 1 and 2). (4) Right ala, with the claw torn off; seen from the inner side. (5) Right half of the carina, with the claw torn away; seen from the outside. (6) The depressed carina, with the protruding anthers and stigma (at a higher level); seen from the side. *a*, calyx; *b*, tube formed by fusion of 9 filaments with the claws of the petals; *c*, vexillum; *d*, hollow on the inner side of the ala; *e*, lower border of ala; *f*, outside of ala; *g*, base of ala dilated into a vesicular process; *h*, carina; *i*, style; *k*, free upper stamen; *l*, stigma; *m*, anthers; *n*, point of fusion between alae and carina; *o*, point at which the carina is moved up and down; *p*, outwardly curved part of the upper margin of the ala; *q*, expansion of the vexillum, folded over below.

The return of the parts to their original position, after removal of the pressure exerted by the insect, is brought about by the intrinsic elasticity of the base of the carina. The thin easily rotated claws of the alae separate from the common tube, and the two large vesicular processes of these petals grasp the reproductive column from above, their elasticity keeping the stamens, pistil, and the parts which enclose them, in their proper positions. The staminal tube is continued into free, stiff, upwardly curved filaments, somewhat thickened at the end; the style curves upwards between them in such a way that the stigma projects above the anthers to some extent.

In order to reach the nectar legitimately, an insect must have a proboscis of at least 9–10 mm. in length, corresponding to that of the corolla-tube. Many species of humble-bee and other bees are regular pollinators, and some Lepidoptera are casual agents of cross-pollination. The pollen, on the other hand, is accessible to all short-tongued insects which are skilful enough to depress the carina. Such insects, e.g. the honey-bee, also effect regular cross-pollination. Nectar is also stolen from the red clover, especially by Bombus terrester (with a proboscis only 7–9 mm. long), and the honey-bee (with a proboscis of 6 mm.); these perforate

the flowers from without, and thrust their proboscis through the hole to the desired booty. The opening is made use of by other thieving insects.

Visitors.—Lindman saw humble-bees and Lepidoptera on the Dovrefjeld. Hermann Müller (H. M.) in Westphalia, Buddeberg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein (S.-H.), in Rügen (R.) on the high ground of Helgoland (H.), and in Thuringia (T.), observed the following.—

A. Diptera. (*a*) *Bombyliidae*: 1. Systoechus sulphureus *Mikan*, vainly seeking for nectar (H. M.). (*b*) *Conopidae*: 2. Sicus ferrugineus *L.*, vainly seeking for nectar (H. M.). (*c*) *Syrphidae*: 3. Volucella bombylans, vainly seeking for nectar (H. M.). **B. Hymenoptera.** *Apidae*: 4. Andrena convexiuscula *K.* ♂, vainly trying to suck (Budd.); 5. A. fasciata *Wesm.* ♀ and ♂, do. (H. M.); 6. A. fulvicrus *K.* ♀, do. (H. M.); 7. A. labialis *K.* ♂, do. (H. M.); 8. A. schrankella *Nyl.* ♀ (H. M.); 9. A. xanthura *K.* ♀, po-cltg. (H. M.); 10. Anthidium manicatum *L.* ♀ and ♂, skg. (H. M.); 11. Anthophora aestivalis *Pz.*, do. (Budd.; Kn., R.); 12. A. pilipes *F.*, do. (H. M.); 13. Apis mellifica *L.* ☿, stealing nectar from flowers perforated by B. terrester, and po-cltg. (H. M.; Kn., S.-H.); 14. Bombus agrorum *F.* ☿ and ♀, skg. (H. M.; Kn., S.-H., R., and T.); 15. B. confusus *Schenck* ☿ and ♀, do. (H. M.); 16. B. derhamellus *K.*, do. (Kn., S.-H.); 17. B. distinguendus *Mor.* ♀, do. (H. M.); 18. B. hortorum *L.*, var. hortorum *L.* ♂, do. (Kn., T. and R.); 19. B. lapidarius *L.* ☿ and ♀, do. (H. M., Kn., S.-H.); 20. B. muscorum *F.*, do. (H. M.); 21. B. pratorum *L.* ☿ (proboscis 8 mm.), ♀ (proboscis 10 mm.), do. (Budd.); 22. B. rajellus *K.* ☿ and ♀, do. (H. M.; Kn., R.); 23. B. sylvarum *L.* ♀, do. (H. M.; Kn., R.); 24. B. terrester *L.*, perforating the corolla and stealing the nectar, even of buds (H. M.; Kn., T.); 25. Cilissa leporina *Pz.* ♂, vainly trying to suck (Budd.); 26. Colletes fodiens *K.* ♀, po-cltg. (H. M.); 27. Diphysis serratulae *Pz.* ♀, do. (H. M.); 28. Eucera difficilis (*Duf.*) *Pér.*, skg. (Kn., Greifswalder I. near R., and H.); 29. E. longicornis ♀ and ♂, do. (H. M.; Kn., S.-H. and H.); 30. Halictus cylindricus *F.* ♀, vainly trying to suck (Budd.); 31. H. flavipes *F.* ♀, po-cltg. (H. M.); 32. H. interruptus *Pz.* ♀, do. (H. M., T.); 33. H. malachurus *K.* ♀, do. (Budd.); 34. H. sexnotatus *K.* ♀, vainly trying to suck (Budd.); 35. H. tetrazonius *Kl.* ♀, do. (Budd.); 36. Megachile circumcincta *L.* ♀, skg. and po-cltg. (H. M.); 37. Osmia aurulenta *Pz.* ♀, po-cltg. (H. M., T.); 38. O. aenea *L.* ♀, skg. and po-cltg. (H. M.); 39. Psithyrus barbutellus *K.* ♀, skg. (H. M.); 40. P. campestris *Pz.* ♀ (H. M.); 41. P. rupestris *F.* ♀, skg. (H. M.; Kn., S.-H.); 42. P. vestalis *Fourcr.* ♀, do. (H. M.). **C. Lepidoptera.** (*a*) *Bombycidae*: 43. Gnophria quadra *L.*, settling on the flowers (H. M.). (*b*) *Noctuidae*: 44. Plusia gamma *L.*, skg. (H. M.; Kn., S.-H.). (*c*) *Rhopalocera*: 45. Argynnis adippe *L.* skg. (Kn., T.); 46. Coenonympha pamphilus *L.* ♀, do. (H. M.; Kn., S.-H.); 47. Epinephele janira *L.*, do. (H. M.; Kn., S.-H.); 48. Hesperia sylvanus *Esp.*, do. (H. M.); 49. H. thaumas *Hfn.*, skg. (Budd.); 50. Melanargia galatea *L.*, freq., skg. (H. M., T.); 51. Papilio podalirius *L.*, skg. (H. M.); 52. Pieris brassicae *L.*, skg. (H. M.; Kn., S.-H., and H.); 53. Pararge megaera *L.*, skg. (H. M.); 54. Vanessa urticae *L.*, skg. (H. M., Kn., H.). (*d*) *Zygaenidae*: 55. Zygaena filipendulae *L.*, skg. (Kn., S.-H.); 56. Z. sp., effecting cross-pollination only occasionally (Kn., R.).

Krieger saw two bees (1. Andrena labialis *K.*; 2. Eucera longicornis *L.* ♀) at Leipzig.

Schmiedeknecht gives the following bees for Thuringia.—

1. Bombus agrorum *F.* ♂; 2. B. distinguendus *Mor.* ♀ and ♂; 3. B. hortorum *L.* ♀ ☿ and ♂; 4. B. lapidarius *L.* ♀ ☿ and ♂; 5. B. latreillellus *K.* (=B. subterraneus *L.*) ♀ ☿ and ♂; 6. B. mastrucatus *Gerst.* ♂; 7. B. mesomelas *Gerst.* ♀ ☿ and ♂; 8. B. muscorum *F.* ♀ ☿ and ♂; 9. B. pomorum *L.* ♀ and ☿, freq., ♂ occasional; 10. B. ruderatus *F.* ♀ ☿ and ♂; 11. B. sylvarum *L.* ♀ and ♂; 12. B. variabilis *Schmiedekn.* ♀ ☿ and ♂; 13. Psithyrus vestalis *Fourcr.* ♀.

Schenck records the following bees for Nassau.—

1. Andrena labialis *K.* ♀ and ♂; 2. A. convexiuscula *K.*; 3. Bombus confusus *Schenck* ♀; 4. B. derhamellus *K.* ♀ ☿ and ♂; 5. B. lapidarius *L.*; 6. B. muscorum *F.* ♀ ☿ and ♂; 7. B. pomorum *Pz.* ♀; 8. Halictus tetrazonius *Klg.* ♀.

The following lists of bees are given as stated.—

Loew (Hesse).—Eucera longicornis *L.* ♀, po-cltg.

Schletterer and von Dalla Torre (Tyrol).—1. Andrena fulva *Schr.* ♀; 2. A. nana *K.* ♀ and ♂; 3. Bombus sylvarum *L.* ♀ and ☿; 4. Chalicodoma pyrenaica *Lep.* ♀.

Schletterer (Pola).—1. Bombus sylvarum *L.*; 2. B. terrester *L.*; 3. Eucera alternans *Brull.*; 4. Megachile pyrenaica *Lep.*

Ducke (Trieste).—1. Andrena korleviciana *Friese* ♀; 2. Eucera difficilis (Duf.) *Pér.* ♀; 3. Osmia aurulenta *Pz.* ♀ and ♂, freq.; 4. Rophites canus *Ev.* ♀ and ♂.

Hoffer (Steiermark).—1. Bombus agrorum *F.* ♀ and ☿; 2. B. hortorum *L.* ♂; 3. B. lapidarius *L.* ♀ and ☿; 4. B. mesomelas *Gerst.* ♀ (v. Dalla Torre); 5. Psithyrus vestalis *Fourcr.* ♂.

Friese (Alsace (A.), Fiume (F.), Mecklenburg (M.), and Hungary (H.)).—1. Andrena convexiuscula *K.*, very freq. (M.); 2. A. labialis *K.*, occasional (H.); 3. Eucera seminuda *Brull.* ♀, do. (H.); 4. Melitta dimidiata *Mor.*, not infreq. (F. and H.); 5. M. leporina *Pz.*, do. (M.); 6. Podalirius fulvitarsis *Brull.* ♀, freq. (A.); 7. P. parietinus *F.*, not infreq. (M.).

Alfken observed the following at Bremen.—

A. Diptera. *Muscidae*: 1. Prosena siberita *F.* **B. Hymenoptera.** *Apidae*: 2. Andrena convexiuscula *K.* ♀ and ♂; 3. A. labialis *K.* ♀ and ♂; 4. Bombus agrorum *F.* ☿ and ♂; 5. B. arenicola *Ths.* ♀ and ☿; 6. B. derhamellus *K.* ♀ ♂ and ☿; 7. B. distinguendus *Mor.* ♀, skg. and po-cltg., ☿ and ♂; 8. B. hortorum *L.* ♀ and ☿, skg. and po-cltg., ♂ skg., var. nigricans *Schmiedekn.* ☿ and ♂, skg.; 9. B. lapidarius *L.* ♀ and ☿, skg. and po-cltg.; 10. B. lucorum *L.* ♀ and ☿ (perforating the tube of the corolla); 11. B. muscorum *F.* ♀; 12. B. pomorum *Pz.* ♀ and ☿; 13. B. ruderatus *F.* ♀ and ☿, skg. and po-cltg.; 14. B. sylvarum *L.* ♀ and ☿, do.; 15. B. subterraneus *L.* ♀ and ☿, do.; 16. Coelioxys quadridentata *L.* ♂, skg.; 17. Eucera difficilis (Duf.) *Pér.* ♀ and ♂; 18. Megachile circumcincta *K.* ♀; 19. M. willughbiella *K.* ♂; 20. Melitta leporina *Pz.* ♀; 21. Osmia caerulescens *L.* ♂; 22. O. claviventris *Ths.* ♂; 23. Podalirius borealis *Mor.* ♀ and ♂, skg.; 24. P. parietinus *F.* ♀, do.; 25. P. retusus *L.* ♂ and ♀; 26. Psithyrus barbutellus *K.* ♀, skg.; 27. P. campestris *Pz.* ♀, do.; 28. P. rupestris; 29. P. vestalis *Fourcr.* ♀, skg.

Verhoeff noticed the following bees in Norderney.—

1. Bombus lapidarius *L.* ♀, skg.; 2. B. latreillellus *K.* (=B. subterraneus *L.*), one ♀; 3. B. terrester *L.* ♀ and ☿ (nectar-thieves), skg.

Alfken saw the following bees in Juist.—

1. Bombus hortorum *L.* ☿ and ♂; 2. B. muscorum *F.* ♀; 3. B. ruderatus *F.* ♂.

Morawitz records Podalirius borealis *Mor.* for St. Petersburg; H. de Vries observed 3 bees (1. Andrena labialis *K.* ♀; 2. A. xanthura *K.* ♀; 3. Apis mellifica *L.* ☿), and 6 humble-bees (1. Bombus agrorum *F.* ☿ and ♂; 2. B. hortorum *L.* ☿ and ♂; 3. B. pratorum *L.* ♂; 4. B. sylvarum *L.* ☿; 5. B. subterraneus *L.*; 6. B. terrester *L.* ☿) in the Netherlands (Ned. Kruidk. Arch., Nijmejen, 2. ser., 2. deel, 1875).

MacLeod saw the following in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 341–2).—Apis, 11 humble-bees, an Eucera, an Andrena, a hover-fly, and 12 Lepidoptera; also 8 humble-bees, an Anthophora, 11 Lepidoptera, a Bombylius, and a hover-fly in the Pyrenees (op. cit., iii, 1891, pp. 435–6).

In Dumfriesshire 3 humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 45).

The variety (*b*) *nivale* (=the species T. nivale *Sieb.*), which lives for the most part above the limit of trees, and bears dirty white instead of red flowers, was seen by Hermann Müller to be visited in the Alps by 7 humble-bees and 17 Lepidoptera, i.e. 71 % of the visitors were of the latter kind. The same investigator noticed that the ordinary variety was visited in the same region by 15 humble-bees, 21 Lepidoptera, and a beetle, i.e. 55 % of the visitors were Lepidoptera ('Alpenblumen,' pp. 241–3).

I may here introduce an observation of Hermann Müller's on a well-known series of inferences.—'The more cats there are, the fewer are the mice; the fewer mice there are, the more abundant are the humble-bees; the more numerous the humble-bees, the more prolific is the red clover; therefore, the more numerous the cats, the more prolific is the red clover.' It is true that humble-bees are the chief pollinators (though not, as Darwin thought, the only ones) of the red clover, but when they are excluded there are numerous nectar-sucking and pollen-collecting insects that can effect the cross-pollination necessary for complete fertility. Hence one link in the above chain of inferences will not hold, for it is wrong to say 'the more numerous the humble-bees, the more prolific is the red clover'. The red clover of New Zealand became wonderfully prolific after the introduction of about 100 humble-bees, there being no indigenous species (Dunning, Proc. Ent. Soc., London, 1886).

690. **T. incarnatum** L.—According to Kirchner ('Flora v. Stuttgart,' pp. 491–2), the flower mechanism of this species essentially agrees with that of T. pratense. The length of the corolla-tube of the bright blood-red flowers is 8–9 mm., and that of the calyx-tube 5 mm. The vexillum is folded up, and therefore serves to guide the proboscis of the longer-tongued insects to the nectar. The base of its limb also completely embraces the claws of the alae and carina, while its own claw is free. The alae possess well-developed vesicular processes, gripping the upper side of the sexual column; also a longitudinal fold, united internally with the epidermis of the carina.

Automatic self-pollination is much less productive than cross-pollination.

VISITORS.—I observed the long-tongued bees Bombus lapidarius *L.* ☿, an Eucera longicornis *L.* ♀ and ♂, in Mecklenburg; both skg. ('Bloemenbiol. Bijdragen').

Höppner saw three humble-bees in Bremen.—1. Bombus agrorum *F.*; 2. B. muscorum *F.*; 3. B. variabilis *Schmiedekn.*

691. **T. alpestre** L. (Herm. Müller, 'Weit. Beob.,' II, pp. 247–8; Schulz, 'Beiträge,' p. 209.)—The flower-heads of this species, according to Hermann Müller, are larger and more brightly coloured than those of T. pratense, with which the flower mechanism agrees in most respects. But while in the latter species the corolla-tube is 7 mm. in length up to the point where carina and vexillum separate, and 11 mm. long measured to the tip of the carina, in the former species these dimensions are 11 mm. and 14 mm. respectively. A great many humble-bees are therefore prevented from sucking nectar legitimately. The carina and alae being shorter than the vexillum, introduction of the proboscis into the flower is rendered more difficult for bees and easier for Lepidoptera. Lastly, the carina is considerably higher than the corolla-tube, and curves sharply upwards, so that the proboscis of a Lepidopterid cannot reach the base of the flower except through the open cleft,

first touching the stigma and then getting dusted with pollen. Hence cross-pollination is regularly effected if another flower has previously been visited. In T. pratense, on the other hand, the proboscis of a Lepidopterid, when similarly introduced, does not touch the stigma and pollen. The blossoms of this species are therefore purely humble-bee flowers, while those of T. alpestre are adapted for cross-pollination by both humble-bees and Lepidoptera.

VISITORS.—Those observed by Hermann Müller in Thuringia correspond with the above interpretation. He found the following.—

A. Hymenoptera. *Apidae*: 1. Eucera longicornis *L.* ♂, skg.; 2. Psithyrus rupestris *F.* ♀, do. **B. Lepidoptera.** *Rhopalocera*: 3. Coenonympha arcania *L.*, trying to suck; 4. C. pamphilus *L.*, do.; 5. Epinephele janira *L.*, do.; 6. Hesperia thaumas *Hfn.*, very freq., skg.; 7. Lycaena semiargus *Rott.*, trying to suck; 8. Melanargia galatea *L.*, in large numbers, skg. or trying to do so; 9. Melitaea athalia *Rott.*, trying to suck; 10. Pieris rapae *L.*, in large numbers, skg.; 11. Syrichthus malvae *L.*, trying to suck.

Loew observed the bees—Eucera longicornis *L.* ♀, po-cltg., in Silesia ('Beiträge,' p. 53); and Bombus pomorum *Pz.*, var. elegans *Seidl.* ☿, in Switzerland (op. cit., p. 62).

Schletterer and von Dalla Torre noticed the leaf-cutting bee Megachile nigriventris *Schenck*, in the Tyrol.

692. T. medium L. (=T. flexuosum *Jacq.*).—Kirchner states ('Flora v. Stuttgart,' p. 492) that the flower mechanism of this species is the same as that of T. pratense, but the flowers are of a brighter red.

VISITORS.—The following have been observed by Herm. Müller (H. M.) in Westphalia, and Buddeberg (Budd.) in Nassau.—

A. Hymenoptera. *Apidae*: 1. Andrena dorsata *K.* ♀, po-cltg. (H. M.); 2. Bombus agrorum *F.* ♀, skg. normally (H. M.); 3. B. muscorum *F.* ♀, skg. (Budd.); 4. B. terrester *L.* ♀, perforating the flower-tube and stealing nectar (H. M., Thuringia); 5. Halictus smeathmanellus *K.* ♀, trying to suck (Budd.); 6. Psithyrus barbutellus *K.* ♀, skg. (Budd.); 7. P. campestris *Pz.* ♀, do. (Budd.). **B. Diptera.** *Syrphidae*: 8. Volucella plumata *L.*, trying to suck (Budd.). **C. Lepidoptera.** *Rhopalocera*: 9. Coenonympha pamphilus *L.*, skg. (H. M., Thuringia); 10. Hesperia lineola *O.*, do. (H. M.); 11. Lycaena semiargus *Rott.*, do. (H. M.); 12. Melanargia galatea *L.*, do. (H. M., Thuringia).

Alfken and Höppner noticed the following bees at Bremen.—

1. Andrena convexiuscula *K.* ♀, po-cltg., ♂; 2. Colletes daviesanus K. ♀; 3. Megachile circumcincta *K.* ♀, po-cltg.; 4. Podalirius borealis *Mor.* ♀, do., ♂.

In Dumfriesshire Apis and 2 humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 45).

693. T. rubens L. (Herm. Müller, 'Fertilisation,' p. 187. 'Weit. Beob.,' II, pp. 248–9.)—According to Hermann Müller, who studied this species in Thuringia, the flower mechanism is intermediate between those of T. pratense and T. alpestre. The purple-red flowers are borne on an elongated axis, all of them being similarly placed and directed obliquely upwards. The upper part of the flower-tube is curved strongly outwards, giving a flexure which corresponds to the most convenient position for the proboscis of long-tongued bees. The corolla-tube is 8–9 mm. long up to the separation of vexillum and carina, and 13–14 mm. to the tip of the carina.

The vexillum projects 1–1½ mm. beyond the carina. The alae are curved outwards almost horizontally, providing visiting bees with a surface to grasp while they press down the carina, as convenient as that of T. pratense, which is formed by the elongation of the vexillum. On the other hand, the place suited for the introduction of the proboscis of Lepidoptera is almost as readily visible as in T. alpestre.

VISITORS.—Those observed by Herm. Müller in Thuringia are adapted to the intermediate character of the flower mechanism. They were the following.—

A. Hymenoptera. *Apidae*: 1. Anthophora retusa *L.* ♀, skg.; 2. Bombus muscorum *F.* ♀, skg., ☿, po-cltg.; 3. B. proteus *Gerst.* ☿, do.; 4. B. sylvarum ♀, do.; 5. B. variabilis *Schmiedekn.*, var. tristis *Seidl.* ☿, skg.; 6. Psithyrus rupestris *F.* ♀, do. **B. Lepidoptera.** (*a*) *Rhopalocera*: 7. Epinephele hyperanthus *L.*, skg.; 8. Hesperia sylvanus *Esp.*, do.; 9. Lycaena corydon *Poda.*, do.; 10. Melanargia galatea *L.*, skg. persistently; 11. Pieris napi *L.*, skg. (*b*) *Sphingidae*: 12. Zygaena filipendulae *L.*, skg.; 13. Z. lonicerae *Esp.*, do. **C. Coleoptera.** *Elateridae*: 14. Corymbites holosericeus *Oliv.*, vainly trying to suck.

Schletterer and von Dalla Torre record the humble-bee Bombus alticola *Kriechb.*, common on Alpine roses, and the leaf-cutting bee Megachile nigriventris *Schenck* (=M. ursula *Gerst.*).

694. T. arvense L. (Herm. Müller, 'Fertilisation,' p. 186, 'Weit. Beob.,' II, p. 248; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 222.)—The small inconspicuous whitish or pink flowers of this species possess a corolla-tube scarcely 2 mm. long. They are fertile when automatically self-pollinated.

VISITORS.—Herm. Müller chiefly observed bees, less frequently Lepidoptera, as follows.—

A. Hymenoptera. (*a*) *Apidae*: 1. Andrena carbonaria *L.* ♂, skg.; 2. A. denticulata *K.*, do.; 3. A. fuscipes *K.* ♂, do.; 4. A. xanthura *K.* ♀, do.; 5. Apis mellifica *L.* ☿, do.; 6. Bombus lapidarius *L.* ☿, do.; 7. B. rajellus *K.* ♀ and ☿, very freq., skg.; 8. Cilissa leporina *Pz.* ♀, skg.; 9. Colletes marginatus *L.* ♂, do.; 10. Diphysis serratulae *Pz.* ♂, do.; 11. Epeolus variegatus *L.*, do.; 12. Halictus flavipes *F.* ♀, do.; 13. H. quadricinctus *F.* ♀, do.; 14. H. zonulus *Sm.* ♀, do.; 15. Megachile argentata *F.* ♂, do.; 16. M. maritima *K.* ♂, do.; 17. Osmia spinolae *Schenck* ♂ (Thuringia); 18. Saropoda bimaculata *Pz.* ♂, freq., skg. (*b*) *Sphegidae*: 19. Ammophila affinis *K.* ♀, skg. **B. Diptera.** *Muscidae*: 20. Gonia capitata *Deg.*, skg. (Buddeberg). **C. Lepidoptera.** *Rhopalocera*: 21. Coenonympha pamphilus *L.*, skg. (Thuringia); 22. Hesperia thaumas *Hfn.*, do.; 23. Lycaena aegon *S. V.*, do.; 24. Polyommatus phlaeas *L.*, do.

On the island of Rügen, I observed the humble-bee Bombus lapidarius *L.* ☿, skg.

Friese mentions for Mecklenburg, on the authority of Brauns and Konow, the very rare bee Andrena nigriceps *K.*

Alfken observed the following bees at Bremen.—

1. Bombus agrorum *F.* ☿; 2. B. derhamellus *K.* ☿; 3. B. lapidarius *L.* ☿; 4. B. pomorum *Pz.* ☿; 5. B. soroënsis *F.*, var. proteus *Gerst.* ☿; 6. Coelioxys quadridentata *L.* ♀, skg.; 7. Colletes marginatus *L.*, freq., ♀ skg. and po-cltg., ♂ skg.; 8. Megachile argentata *F.* ♀ and ♂, do.; 9. Cilissa leporina *Pz.* ♂; 10. Podalirius bimaculatus *Pz.* ♀ and ♂, do. And on the island of Juist.—**A. Diptera.** (*a*) *Asilidae*: 1. Asilus albiceps *Mg.*, very freq., skg. (*b*) *Syrphidae*: 2. Eristalis tenax *L.*; 3. Melithreptus sp.; 4. Syrphus pyrastri *L.*, very freq. **B. Hymenoptera.** *Apidae*: 5. Bombus lucorum *L.* ☿ and ♂; 6. B. muscorum *F.* ☿, freq., skg.; 7. B. terrester *L.* ♀ ☿ and ♂; 8. Colletes marginatus *L.*, freq., skg.

MacLeod saw the bee Halictus flavipes *F.* ♀, in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 350).

In Dumfriesshire a humble-bee and 2 hover-flies have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 45).

695. T. nigrescens Viv.—

Visitors.—Schletterer noticed the following bees at Pola.—

1. Andrena flavipes *Pz.*; 2. A. lucens *Imh.*; 3. A. parvula *K.*; 4. Eucera parvula *Friese*, very frequent; 5. Halictus interruptus *Pz.*; 6. H. levigatus *K.* ♀; 7. H. variipes *Mor.*; 8. Megachile argentata *F.*; 9. M. muraria *L.*; 10. Osmia gallarum *Spin.*; 11. O. tridentata *Duf. et Pér.*; 12. O. versicolor *Ltr.*

696. T. parviflorum Ehrh.—

Visitors.—Schletterer observed the bee Halictus variipes *Mor.* at Pola.

697. T. alpinum *L.* (Herm. Müller, 'Alpenblumen,' pp. 240–1.)—In this species the expanded base of the vexillum surrounds the inner parts of the flower for a length of about 10 mm., so that among all the Alpine Hymenoptera only humble-bees can reach the nectar.

Visitors. — Herm. Müller observed in the Alps 8 species of humble-bee, nect-skg. or po-cltg. (besides Bombus terrester *L.* as a nectar-thief), and 4 species of Lepidoptera skg. or attempting to suck.

Loew noticed the following in Switzerland ('Beiträge,' p. 62).—

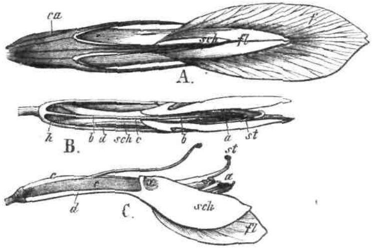


Fig. 94. *Trifolium alpinum*, *L.* (after Herm. Müller). *A.* Flower seen from below (×3½). *B.* The same, after removal of the calyx and vexillum; seen from above: *d*, alar claw. *C.* Anterior part of the same flower, after removal of the right ala, and depression of the carina and left ala; seen from the side. *d*, claw of the carina; *ca*, calyx; *f*, vexillum; *fl*, alae; *sch*, carina; *h*, nectar-passage; *a*, anthers; *b*, upper free filament; *c*, fused filaments; *st*, stigma; *x*, point where the right carinal petal is connected with the right ala.

A. Hymenoptera. *Apidae*: 1. Bombus alticola *Kriechb.* ☿, skg.; 2. B. mucidus *Gerst.* ☿, do.; 3. B. rajellus *K.* ♀, do.; 4. Halictus xanthopus *K.* ♀, po-cltg. **B. Lepidoptera.** *Rhopalocera*: 5. Lycaena sp.

698. T. pallescens Schreb. (Herm. Müller, 'Alpenblumen,' pp. 244–6.)—As the calyx-tube in this species is only 1 mm. long, and the length up to the tip of the carina only 4–5 mm., the nectar concealed in the base of the flower is accessible even to short-tongued bees. The flower mechanism agrees with that of T. repens. Automatic self-pollination is easily effected (see Fig. 95).

Visitors.—Loew observed a short-tongued bee (Andrena) in the Alps ('Beiträge,' p. 63). Herm. Müller, besides the honey-bee and 6 species of humble-bee, also saw 8 species of nect-skg. Lepidoptera.

699. T. badium Schreb. (Herm. Müller, 'Alpenblumen,' pp. 246–7.)—The tiny golden-yellow flowers of this species are scarcely 8 mm. long, and the distance from the tip of the carina to the nectar is hardly 4 mm., so that it is accessible to quite short-tongued bees. Lepidoptera are also easily able to effect cross-pollination, for the stigma is at about the same level as the anthers, surrounded by them, and situated quite at the top of the broad open cleft of the carina (see Fig. 96). In the absence of insect-visits automatic self-pollination readily occurs.

VISITORS.—Herm. Müller observed 4 humble-bees and 11 Lepidoptera.

700. T. agrarium L. (Herm. Müller, 'Weit. Beob.,' II, p. 250; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 350.)—Here again automatic self-pollination is effective.

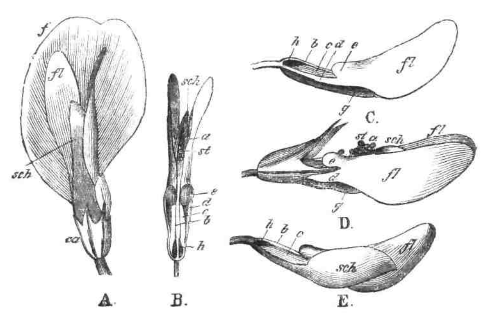


FIG. 95. *Trifolium pallescens, Schreb.* (after Herm. Müller). *A.* Flower seen from below. *B.* The same, after removal of the calyx and vexillum; seen from above. *C.* The same, seen from the side. *D.* Flower after removal of the vexillum, with depressed alae and carina. *E.* Flower after removal of the calyx, vexillum, and right ala; seen from the right side. References as in Fig. 94.

VISITORS.—Hermann Müller gives the following.—

A. Hymenoptera. *Apidae*: 1. Apis mellifica *L.* ☿, skg. **B. Lepidoptera.** *Rhopalocera*: 2. Epinephele hyperanthus *L.*, skg. (Bavarian Oberpfalz); 3. Hesperia lineola *O.*, do.; 4. Lycaena aegon *S. V.* ♂, do.

MacLeod observed the bee Halictus flavipes *F.* ♀ in Flanders.

701. T. campestre Schreb. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 60–1, 153.)—This is a variety of T. procumbens *L.* with larger dark-yellow flowers, which afterwards become brown. In the bud, the large vexillum closely, and almost completely, surrounds the other parts of the flower. On anthesis, the vexillum, which is stiffened by a number of longitudinal veins, serves as a roof by which the alae and the tiny carina, as well as the stamens and pistil, are sheltered. The limbs of the alae are fused with the carina, so that during insect-visits both are depressed together, or laterally displaced, while stamens and pistil project. As the stigma protrudes somewhat further than the anthers, a visitor must first touch the former and then the latter with its ventral surface. When a second flower

is visited, cross-pollination is consequently effected. As anthesis progresses, the brownish tint which replaces the original golden-yellow colour becomes more pronounced. At the same time, the vexillum with its 12–16 wavy ribs, becomes applied to the other parts of the flower, and closes the entrance to them.

VISITORS.—I observed the honey-bee, and Bombus pratorum *L.* ☿ at Kiel; in Sylt only the former.

702. T. procumbens L. (main variety). (Herm. Müller, 'Fertilisation,' p. 187, 'Weit. Beob.,' II, p. 250.)—

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) record the following insects, all skg.—

A. Hymenoptera. *Apidae*: 1. Andrena schrankella *Nyl.* ♀ (Budd.); 2. Apis mellifica *L.* ☿ (H. M.); 3. Halictus flavipes *F.* ♀ (H. M.); 4. H. nitidiusculus *K.* ♀ (Budd.). **B. Diptera.** *Muscidae*: 5. Ocyptera brassicaria *F.* (Budd.). **C. Lepidoptera.** *Rhopalocera*: 6. Epinephele janira *L.* (H. M., Thuringia); 7. Lycaena icarus *Rott.* (H. M.).

MacLeod observed Apis and a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 350).

In Dumfriesshire 3 hover-flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 46).

703. T. minus Relhan. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 153.)—

VISITORS.—In Sylt and Kiel I observed Apis mellifica *L.* ☿, skg. Herm. Müller saw, in addition, Halictus albipes *F.* ♀, skg., and H. cylindricus *F.* ♀, po-cltg.

Alfken noticed the following bees at Bremen.—

1. Andrena parvula *K.* ♀; 2. Nomada succincta *Pz.*

MacLeod observed 3 Lepidoptera in the Pyrenees ('Pyreneënbl.,' p. 437).

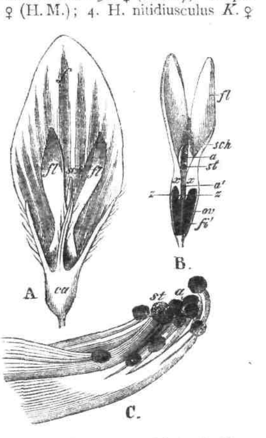


FIG. 96. *Trifolium badium, Schreb.* (after Herm. Müller). *A.* Flower seen from below (× 7). *B.* The same, after removal of calyx and vexillum; seen from above. *C.* Stigma (*st*) and stamens (*a*) in their natural position (× 35). References as in Fig. 94, also: *a'*, upper anther; *fi*, upper filament; *ov*, ovary; *zz*, alar processes.

704. T. subterraneum L. (Warming, Bot. Jahrb., Leipzig, iv, 1883, p. 502; Glaab, D. bot. Monatsschr., Arnstadt, ix, 1890, pp. 20–2; Ross, Malpighia, Genova, v, 1891.)—According to E. Warming, the inflorescence bears but few (usually 3–4) normal flowers which set fruits, and are capable of self-fertilization, though perhaps they do not always effect this. The inflorescence turns downwards, and penetrates into the ground. In order to protect it from injury, the upper vestigial flowers become converted during the period of fruit-forming into peculiar hook-like organs which fix it in the ground, and protect the maturing fruits. The normal flower is almost sessile, while the modified ones possess particularly strong stalks, 2–4 mm. in

length. The lowest of these altered flowers still retain the five calyx-teeth, but all the other parts have become aborted. The higher the flowers on the inflorescence, the feebler are the calyx-teeth; the uppermost flowers are only represented by thick skittle-shaped stalks, somewhat curved, and without a trace of leaves.

The observations of L. Glaab confirm those of Warming, and were made independently. In its first stage the capitulum possesses 3–5 fully formed corollas. While these are fading, the axis of the inflorescence turns downwards, and elongates till at last it reaches the ground, into which it presses the fruits till they sometimes appear half-buried in the soil. Those heads which are more or less surrounded by earth produce the greatest number of fruits and vestigial flowers, as well as the most numerous (3–4) and largest seeds; while those which encounter obstacles, e. g. stones, are relatively retarded in their development.

705. **T. pannonicum** L.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Andrena dorsata *K.* ♀, po-cltg.; 2. Anthophora parietina *F.* ♂ skg., ♀ skg. and po-cltg.; 3. Bombus hortorum *L.* ☿, skg.; 4. Megachile centuncularis *L.* ☿, skg. and po-cltg.

208. Anthyllis L.

Yellow nectar-producing bee flowers with a pumping arrangement, extruding threads of pollen. The tips of all ten filaments are clavate.

706. **A. Vulneraria** L. (Delpino, 'Ult. oss.,' p. 45; Herm. Müller, 'Fertilisation,' pp. 172–3, 'Alpenblumen,' pp. 248–9; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 58, 152; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Frey, 'Lepidopteren der Schweiz,' pp. 16, 20; Schulz, 'Beiträge,' II, p. 208.)—The flower mechanism of this species was first described by Delpino, and afterwards more fully by Hermann Müller, who gives the following account of it.—The greatly elongated claws of the petals are enclosed by a calyx 9–10 mm. long, and somewhat dilated in the middle. From this the vexillum, which is expanded and flat at the end, projects as much as 6–7 mm. It extends somewhat beyond the alae, embracing these above with the grooved base of its limb, while at the same time it grasps and almost completely enfolds them from below by means of two rounded lobes, one on either side of its base. The alae ensheath the carina, with which they are so closely united that it is depressed along with them during insect-visits. The union of these parts is effected in three ways: (1) A narrow, deep groove on the upper side of each ala, near its base, fits into a fold of the carina below it. (2) A pointed triangular tooth, projecting from the outside of this carinal fold fits into the space behind the alar groove. (3) Two internal folds, one from the upper margin of each ala, fairly far forwards, hold these petals firmly together above the carina. The tip of the carina projects immediately in front of these folds, and opens by a slit when the alae are depressed. Behind this slit the upper edges of the carinal petals are fused. The pressure of a bee visiting the flower squeezes out a string of pollen from the slit, pushed from behind by the thickened ends of the ten stamens. The pollen is stored up in the tip of the carina while the flower is still unopened. When the pressure on the alae and carina is removed, these return to their former position, and when the pressure is renewed fresh pollen masses are extruded. At a later

stage the stigma projects through the cleft. To begin with, it is surrounded by the pollen-grains of its own flower, but these do not adhere to its papillae, which are not yet viscid. Not till the pollen has been carried away on the ventral surfaces of insect visitors, are the delicate epidermal cells of the stigma partly rubbed away, making it receptive for pollen from other flowers.

VISITORS.—These are chiefly humble-bees. Herm. Müller observed the following insects.—

A. Hymenoptera. *Apidae*: 1. Bombus agrorum *F.* ♀, skg.; 2. B. hortorum *L.* ♀, do.; 3. B. sylvarum *L.* ☿, do. **B. Lepidoptera.** *Rhopalocera*: 4. Lycaena minima *Fuessl.* ♀, do. **C. Hemiptera.** 5. Capsus sp., attempting to suck.

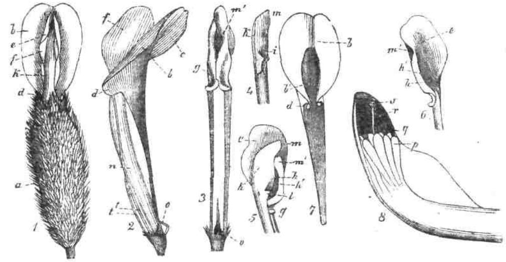


FIG. 97. *Anthyllis Vulneraria, L.* (after Herm. Müller). (1) Flower seen from below. (2) Flower after removal of the calyx, seen from the side. (3) Flower after removal of the calyx and the vexillum, seen from above. (4) Anterior half of the carina, seen obliquely from above and from the left. (5) Anterior half of the carina and an ala, seen from the left side. (6) Left ala (except the base), seen from within. (7) Vexillum, seen from below (× 3½). (8) Tip of the carina after removal of its left half, with the stamens and style, seen from the left side (× 7). *a*, calyx; *b*, lower side of the vexillum; *b'*, groove in the same; *c*, outside of the vexillum; *d*, lobes of the vexillum grasping alae and carina; *e*, inner side of the alae; *f*, outer side of the alae; *g*, deep and narrow fold in the upper external surface of the vexillum, projecting inward as a sharp ridge. This latter fits into a deep fold (*i*) in the upper side of the carina (*k*), and is fixed still more firmly by an acute process (*l*) of the carina, which fits into the space (*h'*) behind the sharp ridge (*h*); *m*, opening in the carina through which the pollen passes out; *m'*, anterior fold in the upper margin of the ala; *n*, column of reproductive organs; *o*, nectar-passages; *p*, thickened ends of the filaments; *q*, empty anthers; *r*, pollen; *s*, stigma; *tt*, claws of the alae.

Kerner saw a butterfly, Lycaena hylas *Esp.*: the female lays her eggs in the ovary. Frey states that the caterpillars of this butterfly live only on Thymus Serpyllum and Coronilla varia, while the caterpillars of Lycaena minima *Fuessl.* and L. semiargus *Rott.* live on Anthyllis. This also agrees with Herm. Müller's observations.

Herm. Müller observed 10 Apidae, 10 Lepidoptera, and 2 beetles in the Alps.

Alfken noticed 3 humble-bees in Juist.—

1. Bombus hortorum *L.* ☿, very freq.; 2. B. lapidarius *L.* ☿, do.; 3. B. muscorum *F.* ☿, do.

MacLeod saw 4 humble-bees, an Anthophora, 5 Lepidoptera, and a Dipterid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 435). Loew observed two bees in Switzerland ('Beiträge,' p. 61), i. e. Bombus pomorum *Pz.*, var. elegans *Seidl.* ☿, po-cltg., and Eucera longicornis *L.* ♀, do.; also Bombus agrorum *F.* ☿, skg., in the Berlin Botanic Garden.

In Dumfriesshire a humble-bee was recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 47).

Schulz noticed the perforation of flowers by humble-bees.

For the variety maritima *Schweig.*, the flower mechanism of which agrees with the type-form, I observed humble-bees (Bombus agrorum *F.*) in Schleswig-Holstein, and, in the island of Föhr, 2 Lepidoptera as useless guests, nect-skg., i. e. Epinephele janira *L.* and Zygaena filipendulae *L.*

Schletterer saw the Scoliid Scolia flavifrons *F.*, var. haemorrhoidalis *F.*, on the variety A. Dillenii *Schult.*, at Pola.

707. **A. montana** L.—According to Briquet ('Études d. biol. flor. dans les Alpes occident') the bright rose-red flowers of this species possess a pumping arrangement essentially agreeing with that of A. vulneraria.

Visitors.—These are honey-bees, humble-bees, and also Lepidoptera, which effect cross-pollination after removing the pollen. Automatic self-pollination is improbable (Kirchner).

209. Lotus Tourn.

Like the last genus. Only the five outer filaments are club-shaped at the tip.

708. **L. corniculatus** L. (Delpino, 'Sugli appar. d. fecondaz. nelle piante autocarp.,' p. 25; Herm. Müller, 'Fertilisation,' pp. 167–71, 'Weit. Beob.,' II, pp. 245–6, 'Alpenblumen,' pp. 238–40; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 350–3; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 61–2, 153, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 233, 'Bl. u. Insekt. a. d. Halligen,' 'Blütenbiol. Beob. a. d. Ins. Rügen'; Loew, 'Blütenbiol. Floristik,' pp. 391, 395, 399; Schulz, 'Beiträge,' II, p. 209; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.) — The flower mechanism of this species was first indicated by Delpino, and subsequently fully described in a masterly way by Hermann Müller. The following is an abstract of his account.—The vexillum of the golden-yellow flowers, of which there are five in a head, is perpendicular, and frequently possesses red streaks as nectar-guides. The nectar, secreted in the usual place, is sought out by numerous insects. Only Hymenoptera are effective pollinators; various Lepidoptera and Diptera are unbidden guests. Each ala possesses a deep depression near the base of its limb, which fits into a corresponding pit in the upper side of the carina. Immediately behind this point, the upper edges of the alae are fused together, so that when a suitable insect visits the flower both alae and carina must simultaneously be depressed. Even in the bud, before the petals are fully developed, the ten anthers dehisce, discharging their pollen into the tip of the carina, after which they shrivel. As the flower grows, only the filaments of the five outer stamens elongate, while at the same time their ends thicken, and completely cut off the conical tip of the carina from its lower part. A pollen-chamber is thus constituted; it conceals the stigma, and there is a slit along its upper margin. As a result of pressure exerted by a nectar-seeking insect, the five thickened ends of the filaments penetrate further into the tip of the carina, and a corresponding quantity of pollen passes out piecemeal through the carinal opening. As the downward pressure increases, the stigma also protrudes, so that

either cross- or self-pollination may take place. The latter, however, is ineffective. When the pressure is removed, the parts of the flower return to their original positions. Automatic self-pollination, by the pollen surrounding the stigma of an unvisited flower, does not take place, for it appears that the stigmatic papillae must be rubbed before becoming receptive. Kerner states, however, that the flowers are fertile when insects are excluded. Warnstorf describes the pollen-grains as very small, shining, white, and smooth, resembling blunt-ended prisms in shape, with a slight constriction in the middle. On an average they are 25 μ long and 12 broad.

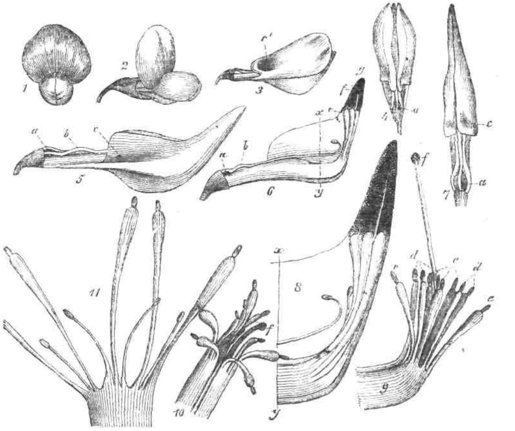


FIG. 98. *Lotus corniculatus*, *L.* (after Herm. Müller). (1) Flower seen from the front. (2) Flower seen obliquely from the side. (3) Flower after removal of the vexillum, seen from the side. (4) The same, seen from above. (5) Flower after removal of the vexillum and alae, seen from the side, and more highly magnified. (6) Flower after removal of the right half of the carina, seen from the right side. (7) Flower after removal of the vexillum and alae, seen from above. (8) The stamens, style, and stigma, enclosed in the anterior part of the carina, more highly magnified than in 6. (9) Stamens, style, and stigma of a bud, immediately after the pollen has been shed; removed from the flower and seen from the side. The outer filaments have become thicker than they were in 8. (10) The same, seen from above; the outer filaments, thickened at the end, spread out, being freed from the pressure of the carina. (11) The nine united filaments of a fully developed flower spread out. *a*, nectar-passage; *b*, upward bend of the free filament; *c*, depressions in the two carinal petals, into which projections (*c'*) of the alae fit; *d*, the five inner filaments that remain short; *e*, the five outer filaments, which elongate and become club-shaped; *f*, stigma; *e–g*, hollow cone of the carina filled with pollen; *g* carinal opening from which pollen is pressed out; *xy* indicates corresponding parts of 6 and 8.

VISITORS.—Hermann Müller (H. M.) in Westphalia, Buddeburg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein (S.-H.), Rügen (R.) and Thuringia (T.), observed the following.—

A. Hymenoptera. *Apidae*: (*a*) Dasygastres: 1. Anthidium manicatum *L.* ♀ (H. M.); 2. A. oblongatum *Ltr.*, freq., ♀, skg. and po-cltg., ♂ (H. M., Budd.); 3. A. punctatum *Ltr.* ♀ and ♂, do. (H. M., Budd.); 4. A. strigatum *Ltr.* ♀ and ♂, do.

(Budd., Kn., T.); 5. Chelostoma nigricorne *Nyl.* ♂, skg. (Budd.); 6. Diphysis serratulae *Pz.* ♀ and ♂, skg. and po-cltg. (H. M., Budd.); 7. Megachile argentata *F.* ♀ and ♂, skg. (H. M., Budd.); 8. M. circumcincta *K.* ♀ and ♂, freq. (H. M., Budd., Kn., S.-H. and R.); 9. M. fasciata *Sm.* ♀ and ♂, skg. and po-cltg. (Budd., H. M., T.); 10. M. analis *Nyl.*, var. obscura *Alfk.* (Kn., Langeness); 11. M. pyrina *Lep.* ♀ and ♂, freq. (H. M.); 12. M. willughbiella *K.* ♀ and ♂, skg. and po-cltg. (H. M., Budd.); 13. Osmia adunca *Pz.* ♀ and ♂, do. (Budd.); 14. O. aenea *L.* ♀ and ♂, freq., skg. and po-cltg.; 15. O. aurulenta *Pz.* ♀, very freq. (H. M., Budd.); 16. O. claviventris *Ths.* ♀ (H. M.); 17. O. fuciformis *Ltr.* ♀, skg. (H. M., T.); 18. O. pilicornis *Sm.* ♀ (Budd.); 19. O. rufa *L.* ♀ and ♂, skg. (H. M., Budd.). (*b*) Scopulipedes: 20. Andrena convexiuscula *K.* ♀, skg. and po-cltg. (H. M.); 21. A. labialis *K.* ♀, skg. (H. M.); 22. A. xanthura *K.* ♀. po-cltg. (H. M.); 23. Anthophora quadrimaculata *Pz.* ♀ (Kn., S.-H.); 24. Apis mellifica *L.* ☿, very freq., skg., more rarely po-cltg. (H. M.; Kn., S.-H., and R.); 25. Bombus agrorum *F.* ♂ ♀ and ☿, skg., more rarely po-cltg. (H. M., Budd., Kn.); 26. B. derhamellus *K.* ☿ (Kn.); 27. B. lapidarius *L.* ☿, skg. (H. M., T.; Kn., S.-H. and T.); 28. B. pratorum *L.* ☿ (Budd.); 29. B. muscorum *F.* ☿, skg. (H. M., T.; Budd.), ♀ (Kn.); 30. B. sylvarum *L.* ☿, skg. (H. M., T.); 31. B. terrester *L.* ☿, skg., more rarely po-cltg. (H. M.; Kn., S.-H. and T.); 32. Cilissa haemorrhoidalis *F.* ♂, skg. (Budd.); 33. C. leporina *Pz.* ♀, do. (Budd.); 34. Eucera longicornis *L.* ♀ and ♂, do. (H. M., Budd.); 35. Halictus flavipes *F.* ♀, do. (H. M.); 36. H. leucopus *K.* ♀ (Budd.); 37. H. leucozonius *Schr.* ♀ (Budd.); 38. H. levigatus *K.* ♀ (Budd.); 39. H. rubicundus *Chr.*, skg. and po-cltg. (H. M.); 40. H. sexnotatus *K.* ♀ (Budd.); 41. H. smeathmanellus *K.* ♀ (Budd.); 42. Rhophites canus *Eversm.* ♀ and ♂ (H. M., T.). (*c*) Cuckoo-bees: 43. Coelioxys elongata *Lep.* ♀, skg. (H. M., T.); 44. C. sp. ♂, do. (H. M.); 45. Nomada ruficornis *L.* ♀, do. (H. M.). **B. Coleoptera.** (*a*) *Elateridae*: 46. Agriotes sputator *L.*, vainly seeking for nectar (H. M., T.). (*b*) *Mordellidae*: 47. Mordella fasciata *F.*, vainly seeking for nectar (H. M., T.). **C. Diptera.** (*a*) *Conopidae*: 48. Conops flavipes *L.*, skg., inserting its proboscis under the vexillum (H. M.); 49. Myopa testacea *L.*, skg. (Budd.). (*b*) *Syrphidae*: 50. Melanostoma mellina *L.*, po-dvg. (H. M.). **D. Lepidoptera.** (*a*) *Bombycidae*: 51. Porthesia similis *Fuessl.*, vainly skg. (H. M.). (*b*) *Noctuidae*: 52. Euclidia glyphica *L.*, skg. (H. M.); 53. Plusia gamma *L.* (H. M.). (*c*) *Rhopalocera*: 54. Coenonympha arcania *L.*, skg. (H. M.); 55. C. pamphilus *L.*, do. (Kn.); 56. Epinephele janira *L.*, do. (Kn.); 57. Syrichthus malvae *L.*, do. (H. M.); 58. Nisoniades tages *L.*, do. (H. M.); 59. Lycaena aegon *S. V.*, do. (H. M., T.); 60. L. damon *S. V.* (H. M., T.); 61. L. icarus *Rott.*, skg. (H. M.); 62. L. semiargus *Rott.* (Kn.); 63. L. sp. (Kn.); 64. Thecla spini *S. V.*, skg. (H. M.). (*d*) *Sphingidae*: 65. Sesia empiformis *Esp.*, skg. (H. M., T.); 66. Zygaena filipendulae *L.*, do. (H. M., T.; Kn.); 67. Z. sp., do. (Kn., R.).

Herm. Müller saw 17 Apidae, 25 Lepidoptera, and a hover-fly in the Alps.

For the Tyrol von Dalla Torre gives the humble-bees Bombus mastrucatus *Gerst.* ♂, and B. pratorum *L.* ☿ and ♂. Schletterer saw both these, and also the following bees, at Pola.—

1. Andrena albopunctata *Rossi*; 2. A. convexiuscula *K.*; 3. A. cyanescens *Nyl.*; 4. A. deceptoria *Schenck*; 5. A. flavipes *Pz.*; 6. A. parvula *K.*; 7. Halictus levigatus *K.* ♀; 8. Osmia andrenoides *Spin.*; 9. O. aurulenta *Pz.*; 10. O. latreillei *Spin.*; 11. O. ligurica *Mor.*

Ducke noticed the following bees at Trieste.—

1. Meliturga clavicornis *Ltr.*; 2. Osmia aurulenta *Pz.*; 3. O. tiflensis *Mor.* ♀, occasional; 4. O. versicolor *Ltr.* ♀ and ♂, very freq.; 5. The southern var. of the parasitic species Psithyrus barbutellus *K.* (=P. maxillosus *Klug*) ♀.

Alfken saw the following bees at Bad Ratzes in the Tyrol.—

1. Anthidium strigatum *Ltr.* ♀ and ♂, freq.; 2. Megachile willughbiella *K.* ♀, freq., skg.; 3. Trachusa serratulae *Pz.*, very freq.; to which Kohl adds a mason-bee, 4. Osmia claviventris *Ths.*

Alfken observed the following bees at Bremen.—

1. Anthidium strigatum *Pz.* ♀, skg. and po-cltg., ♂ skg.; 2. Andrena convexiuscula *K.* ♀, skg. and po-cltg.; 3. A. labialis *K.* ♀; 4. Bombus agrorum *F.* ♀ and ☿; 5. B. arenicola *Ths.* ☿; 6. B. derhamellus *K.* ♀ and ☿; 7. B. distinguendus *Mor.* ☿; 8. B. hortorum *L.* ☿; 9. B. lapidarius *L.* ☿; 10. B. muscorum *F.* ♀ and ☿; 11. B. sylvarum *L.* ☿; 12. B. variabilis *Schmiedekn.* ☿; 13. Coelioxys quadridentata ♀, skg.; 14. C. mandibularis *Nyl.* ♀, do.; 15. C. rufescens *Lep.* ♀, do.; 16. Eucera longicornis *L.* ♀; 17. Halictus calceatus *Scop.*; 18. H. rubicundus *Chr.* ♀; 19. H. tumulorum *L.* ♀; 20. Megachile analis *Nyl.* ♀ and ♂; 21. M. centuncularis *L.* ♀ and ♂; 22. M. circumcincta *K.* ♀ and ♂; 23. M. maritima *K.* ♀ and ♂; 24. M. willughbiella *K.* ♀ and ♂; 25. Melitta leporina *Pz.* ♂; 26. Nomada jacobaeae *Pz.* ♀, skg.; 27. N. ochrostoma *K.* ♀; 28. Osmia claviventris *Ths.* ♀; 29. Podalirius vulpinus *Pz.* ♀; 30. Trachusa serratulae *Pz.* ♀ and ♂.

Alfken (A.) and Leege (L.) record the following for Juist.—

A. Hymenoptera. *Apidae*: 1. Bombus hortorum *L.* ☿, po-cltg. and skg.; 2. B. lapidarius *L.* (L.); 3. B. muscorum *F.* (L.); 4. Megachile circumcincta *K.* ♀, rare, po-cltg. and skg. (A., L.); 5. Osmia maritima *Friese* ♀, very freq., po-cltg. and skg. (A., L.); 6. Psithyrus rupestris *L.* (L.). **B. Lepidoptera.** *Sphingidae*: 7. Deilephila galii *Rott.*, very freq. (L.); 8. D. porcellus, *L.*, do. (L.).

Verhoeff gives the following for Norderney and Juist (J.).—

A. Coleoptera. *Staphylinidae*: 1. Anthobium torquatum *Marsh.*, abnormal (J.). **B. Hymenoptera.** *Apidae*: 2. Bombus cognatus *Steph.* (=B. muscorum *F.*) ♀, skg. (J.); 3. B. hortorum *L.* ♀, do. (J.); 4. B. lapidarius *L.* ♀, freq., skg. and po-cltg.; 5. B. terrester *L.* ☿, skg., sometimes abnormally (J.); 6. Halictus minutus *K.* ♀, abnormal; 7. Megachile circumcincta *K.* ♀, skg.; 8. Osmia maritima *Friese* ♀ and ♂, do., ♀ skg. (J.). **C. Lepidoptera.** (*a*) *Nymphalidae*: 9. Vanessa cardui *L.*, abnormal. (*b*) *Lycaenidae*: 10. Lycaena icarus *Rott.*, abnormal (also J.). (*c*) *Pieridae*: 11. Pieris brassicae *L.*, abnormal (also J.).

Friese observed the following bees in Alsace (A.), Baden (B.), at Innsbruck (I.), in Mecklenburg (M.), Switzerland (S.), Thuringia (T.), and the Tyrol (Ty.).—

1. Anthidium montanum *Mor.*, infrequent (S.); 2. A. oblongatum *Ltr.*, not uncommon (T.); 3. A. punctatum *Ltr.* (A., M.; rare in S., T., and Ty.); 4. A. strigatum *Pz.*; 5. Coelioxys elongata *Lep.* (T.); 6. C. quadridentata *L.*; 7. Eucera difficilis *Duf.*, occasional (B.); 8. E. interrupta *Baer*, do. (B.); 9. E. longicornis *L.*, freq. (B.); 10. Megachile apicalis *Spin.*, occasional (M.); 11. M. argentata *F.*, freq. (M.); 12. M. centuncularis *L.*, do. (M.); 13. M. circumcincta *K.*, do. (A., B., M., T.); 14. M. ericetorum *Lep.*, occasional (A.); 15. M. muraria *Retz.*, freq. (A.); 16. M. pyrenaica *Lep.*; 17. Osmia aurulenta *Pz.*, freq. (M.; rare in A. and B.); 18. O. bicolor *Schr.* ♀, skg. (A.); 19. O. claviventris *Ths.* (B.; rare in M.; occasional, A., T., S.); 20. O. nigriventris *Zett.*, infrequent (S.); 21. lepeletieri *Pér.* ♀ and ♂ (I., S.); 22. O. leucomelaena *K.*, occasional (M.); 23. O. maritima *Friese*, Freq. (M.); 24. O. morawitzi *Gerst.*; 25. O. vulpecula *Gerst.* (S.); 26. Podalirius bimaculatus *Pz.*, not infrequent (M.); 27. Trachusa serratulae *Pz.*, occasional (A., B., M., S., T.).

Rössler saw the moth Butalis aeneospersella *Roslr.* at Wiesbaden, and Krieger the following bees at Leipzig.—

1. Anthidium strigatum *Pz.*; 2. Bombus derhamellus *K.* ☿; 3. Megachile centuncularis *L.*; 4. Osmia rufa *L.*; 5. Podalirius vulpinus *Pz.*; 6. Trachusa serratulae *Pz.*

Schenck records the following Hymenopterids.—

(*a*) *Apidae*: 1. Anthidium oblongatum *Ltr.*; 2. A. punctatum *Ltr.*,; 3. Andrena labiata *Schenck*; 4. Megachile argentata *F.*; 5. M. maritima *K.*; 6. Podalirius bimaculatus *Pz.* (*b*) *Vespidae*: 7. Odynerus xanthomelas *H.-Sch.*

Schmiedekneckt gives the bees Osmia aurulenta *Pz.* for Thuringia, and O. difformis *Pér.* for the Pyrenees; while Gerstäcker noticed two bees at Berlin—Coelioxys quadridenta *L.* and Osmia tridentata *Duf. et Perr* (one ♀).

Loew observed the hover-fly Eristalis tenax *L.*, po-dvg., in Silesia, and the following bees in Brunswick (B.) ('Beiträge,' p. 53), Mecklenburg (M.), (op. cit., p. 44), Switzerland (Sw.) and the Tyrol (T.) (op. cit., p. 61).—

1. Diphysis serratulae *Pz.* ♀, po-cltg. (B.); 2. Cilissa tricincta *K.* ♀, do. (M.); 3. Colletes fodiens *K.* ♀, do. (M.); 4. Megachile argentata *F.* ♀, do. (M.); 5. M. willughbiella *K.* ♂, skg. (M.); 6. Chalicodoma muraria *Retz.* ♀, po-cltg. (T.); 7. Eucera longicornis *L.* ♀, do. (Sw.); 8. Megachile analis *Nyl.* ♀, do. (Sw.); 9. Osmia angustula *Zett.* (T.).

MacLeod saw Apis, 5 humble-bees, Diphysis, and 5 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 352–3); and 11 long-tongued bees, 7 Lepidoptera, and a fly in the Pyrenees (op. cit., iii, 1891, pp. 437–8).

In Dumfriesshire, Apis, 2 humble-bees, a short-tongued bee, a hover-fly, and a beetle were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 47).

In England, Saunders observed the leaf-cutting bee Megachile versicolor *Sm.*, and Smith the wall-bee Osmia aurulenta *Pz.*

Schulz in Central Germany noticed flowers perforated by humble-bees.

Only bees are able to liberate the flower mechanism; other visitors are unbidden guests.

709. L. uliginosus Schkuhr (= L. major *Sm.*). (MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 353; Kirchner, 'Flora v. Stuttgart,' p. 494; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 62, 153, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 233, 'Blütenbiol. Beob. a. d. Ins. Rügen'; Schulz, 'Beiträge,' II, p. 209; Warnstorf, Verh. bot. Ver., Berlin, xxxv, (1893) 1894.) — The flower mechanism of this species is exactly like that of L. corniculatus, but the carina is longer and narrower, and is not exactly vertical—but directed obliquely upwards. Perhaps, therefore, rather less pressure suffices to work the pumping apparatus. Warnstorf states that the pollen-grains are only 18–19 μ long and 12 μ broad, but otherwise like those of L. corniculatus.

Visitors.—In the island of Föhr, I only observed the honey-bee; in Rügen I saw Bombus rajellus *K.* ☿, skg., and also a moth (Zygaena filipendulae *L.*) as an unbidden guest. Schulz noticed flowers perforated by humble-bees in Central Germany.

In Thuringia I only observed a moth, Zygaena trifolii *Esp.* (an unbidden guest) ('Blütenbiol. Beob. in Thüringen,' p. 42).

H. de Vries saw a humble-bee (Bombus subterraneus *L.* ☿) in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875). MacLeod observed Apis, 2 humble-bees, a hover-fly, and 2 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 353).

Willis noticed a humble-bee, Bombus agrorum *F.*, skg., in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).

210. Tetragonolobus Scop.

Agrees with Lotus.

710. T. siliquosus Roth.—Hermann Müller ('Alpenblumen,' p. 238) describes the mechanism of the large yellow humble-bee flowers of this species. A proboscis 12–14 mm. in length is required to secure all the nectar. Kirchner ('Beiträge,' p. 42) adds that the somewhat S-shaped style thickens towards its end, becoming *thinner again for the last millimetre. The stigma is situated here, on the side* directed outwards and upwards, and indented.

VISITORS.—These are undoubtedly humble-bees, but the nectar is concealed so deeply that it can only be reached by long-tongued species. A. Schulz says that, in Central Germany, shorter-tongued species steal the nectar by perforating the flowers. Loew observed Bombus lapidarius *L.* ☿, skg. in the Berlin Botanic Garden. MacLeod noticed 2 humble-bees and an Osmia in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 437).

211. Amorpha L.

Protogynous nectar-yielding flowers, devoid of carina and alae.

711. A. fruticosa L.—As emphasized by Delpino ('Ult. oss.,' pp. 64–8), and subsequently by Hermann Müller ('Weit. Beob.,' II, pp. 244–5), the flowers of this species, which has been introduced into Europe from North America, have neither alae nor carina, so that the vexillum alone enfolds the stamens and pistil in the bud. When first the flower opens, only the style with its stigma already receptive projects beneath the vexillum, while the still immature anthers are concealed beneath it. The stamens soon elongate, however, so that they often project beyond the stigma. If the latter has not already been pollinated it remains receptive till the anthers dehisce, so that self-pollination takes place should insect-visits fail. If, however, these take place, cross-pollination is secured as a result of protogyny.

VISITORS.—Herm. Müller observed the honey-bee, very freq., skg. and po-cltg. As the individual flowers do not possess alighting- or supporting-surfaces (alae and carina), bees use the whole inflorescence as such.

712. A. canescens Nutt.—The flower mechanism is like that of A. fruticosa.

212. Galega Tourn.

Nectarless bee flowers, lilac or white in colour; with a simple valvular arrangement.

713. G. officinalis L. (Kirchner, 'Beiträge,' p. 42.)—The flowers of this species are arranged in erect racemes of considerable size. The calyx-tube is $2\frac{1}{2}$ mm., and the lamina of the vexillum 9 mm. in length. At the base of the latter there is a bright median streak. The carina projects from the calyx as much as the vexillum, but the alae are a little shorter. Each alar lamina possesses a posterior process which is directed obliquely upwards and overlaps the staminal tube. In front of this process there is a deep projection which fits into a corresponding fold of the carina, and brings about a firm union. The stigma and anthers project freely from the carina when the alae are depressed, resuming their position when

the pressure is removed. The upper filament is free distally, but its proximal half is fused with the other nine, so as to leave no access to the base of the inner surface of the staminal tube. This is in correspondence with the absence of nectar. The anthers shed their reddish-yellow pollen before the flower opens.

213. Colutea L.

Nectar-yielding bee flowers, mostly yellow in colour; with a brush arrangement.

714. **C. arborescens** L. (Kirchner, 'Beiträge,' pp. 42–3; Loew, 'Blütenbiol. Floristik,' p. 395; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 233, 'Bloemenbiol. Bijdragen.')—In this species, according to Kirchner, the thick-walled calyx and the strong elastic claws keep the petals in place, and cause them to return to their original position when the pressure exerted by an insect visitor is removed. *The vexillum is erect, and possesses a faintly marked nectar-guide.* At the base of its lamina there are two swellings, closely apposed to the alae. The latter are small, and not united with the carina. Each possesses a finger-shaped process, carried obliquely downwards and grasping the sexual column behind. The large strong carina possesses two posteriorly directed triangular lappets which serve the same purpose: its front part is thickened, so that the upper edges of the carinal petals are kept close together.

The style projects about 3 mm. beyond the anthers, and is rolled at the end in such a way that its apex points downwards. On its inner side it bears a brush about 5 mm. long directed obliquely upwards. The end of the style is obliquely truncated, presenting a surface from the middle of which the small papilliform stigma projects. This is surrounded by hairs which prevent self-pollination from taking place.

Considerable pressure is required to depress the carina. When this is effected, the style with its adherent pollen first protrudes, and then the anthers. These dehisce shortly before the flower opens, and part of the pollen which covers them gets transferred to the hairs on the style.

Kirchner observed a great many honey-bees visiting this species. Some of them sucked legitimately, having settled on the middle of the flowers and succeeded in depressing the alae and strong carina, so that the stigma and anthers protruded. In doing so, they frequently effected self-pollination, though many of them dusted the stigma with pollen brought on their legs from other flowers. Most of the visitors, however, preferred to thrust in their proboscis laterally between vexillum and alae, without causing protrusion of the sexual organs from the carina. Sometimes all the bees visiting one particular shrub sucked legitimately, while all those which settled on another stole the nectar. Humble-bees were also seen inserting the proboscis obliquely into the bases of the flowers without depressing the carina. My own observations essentially agree with those of Kirchner.

Visitors.—Apis mellifica *L.* ☿ appears frequently as a visitor. At Kiel (17. 6. '96) and Sonderburg, in the island of Alsen (1. 8. '96), I almost always observed it to settle on the side of the blossoms, skg. laterally without operating the flower mechanism. *Sometimes a bee would try to suck legitimately, but was too weak to* force its way into the almost closed flowers. A humble-bee (Bombus lapidarius

L. ♀) succeeded in doing this without any special effort, at the same time effecting cross-pollination. I observed the same species of humble-bee in the island of Pellworm (4. 6. '93).

Schletterer records two bees for the Tyrol:—1. Melecta luctuosa *Scop.*; 2. Podalirius tarsatus *Spin.* He observed the Ichneumonid Perithous mediator *F.* at Pola.

Loew noticed the bee Megachile lagopoda *L.* ♀, po-cltg. in the Harz district ('Beiträge,' p. 52).

Kerner states that a butterfly (Lycaena baetica *L.*) visits the flowers, the female laying her eggs in the ovary ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 156).

214. Glycyrrhiza Tourn.

715. **G. grandiflora** Tausch.—

VISITORS.—Loew saw the honey-bee, skg., in the Berlin Botanic Garden.

215. Tephrosia Pers.

716. **T. heterantha** Griseb.—Hieronymus states that this species produces cleistogamous flowers (Jahresber. Ges. vaterl. Cultur, Breslau, 1897).

216. Robinia L.

White or reddish nectar-yielding bee flowers; with brush arrangement.

717. **R. Pseud-acacia** L. (Kirchner, 'Flora v. Stuttgart,' pp. 495–6; Knuth, 'Bloemenbiol. Bijdragen.')—The odorous white flowers of this species are arranged in large pendulous racemes. The vexillum has a green nectar-guide. Kirchner states that the upper edges of the carinal petals are closely apposed: there is the usual posterior hollow for union with the alae. The carina, alae, and sexual column are mainly held together by the vexillum, the lower part of which grasps all of them by means of two well-developed elastic lobes. The posterior processes of the alar laminae also surround the sexual column, so long as the alae are gripped by the vexillum, for the alar claws are twisted outwards at the back, thus pressing the laminae inwards and downwards. The anthers dehisce before the flower opens; pollen collects among the hairs of the stylar brush, but protective bristles prevent it from reaching the stigma. The perpendicular style is 6 mm. long, and the terminal capitate stigma is surrounded by a circlet of protective bristles directed obliquely upwards. Below these comes a hairless region about $\frac{1}{4}$ mm. long, while the part underneath this carries a brush of collecting-hairs crowded together externally into a tract about $\frac{1}{2}$ mm. long, more loosely arranged internally, and stretching over a distance of from $1\frac{1}{2}$ to 2 mm. (see Fig. 99). I was able to satisfy myself that the stigma remains sticky and receptive long after the anthers dehisce and the pollen has been removed.

FIG. 99. *Robinia Pseud-acacia, L.* (From nature.) 1. The pistil seen from the side. 2. Stigma (*s*) seen from above. (Enlarged.)

During insect-visits the stigma first projects from the tip of the carina, and then the pollen, both returning to the carina on removal of the pressure.

Visitors.—These are bees, of which I observed:—1. Apis mellifica *L.*, skg.; 2. Bombus agrorum *F.*, do.

718. R. viscosa Vent. (= R. glutinosa *Sims*). (Knuth, 'Bloemenbiol. Bijdragen.')—This is a North American species, not infrequently cultivated in Europe as an ornamental tree. The flowers are of a bright flesh-colour, and arranged in dense racemes. There is a bright yellow nectar-guide on the vexillum. The brush on the style resembles that of R. Pseud-acacia. The upper free filament is fused for about half its length with the staminal tube.

Visitors.—At Kiel and Rendsburg I observed two bees, freq. skg. (28. 6 to 1. 7. '96):—1. Apis mellifica *L.* ☿; 2. Bombus lapidarius *L.* ☿.

217. Caragana Lam.

719. C. arborescens Lam. (= Robinia Caragana *L.*).—

Visitors.—Kirchner observed a humble-bee (Bombus lapidarius *L.* ☿), skg. legitimately, in Wurtemberg ('Beiträge,' p. 43).

218. Phaca L.

Nectar-yielding bee flowers, usually yellowish or violet in colour; with simple valvular arrangement.

720. P. alpina Jacq. (Herm. Müller, 'Alpenblumen,' pp. 236–7.)—In the flowers of this species the nectar is concealed at a depth of 9–10 mm. The petals are so close together that it is doubtful whether the numerous Lepidoptera that are attracted by the marked conspicuousness of this plant succeed in reaching the nectar, even when they have a proboscis of sufficient length. Probably only long-tongued humble-bees are able to do this. It is doubtful whether self-pollination takes place.

Visitors.—Herm. Müller observed 4 humble-bees and 9 Lepidoptera in the Alps.

Loew noticed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.*, flying in numbers around the flowers and settling both on the alae and the carina, po-dvg. (?). **B. Lepidoptera.** *Rhopalocera*: 2. Pieris napi *L.*, skg.

721. P. frigida L. (Herm. Müller, 'Alpenblumen,' pp. 237–8.)—In this species *self-pollination is possible in the Alps in individual cases. According to* Axell ('Om Anord. för Fanerog. Växt. Befrukt.,' p. 17), the flowers are homogamous in the Scandinavian highlands; but Lindman says that the anthers ripen in the bud, before the stigma becomes receptive. In this region automatic self-pollination takes place in fully matured flowers when the weather is favourable, but when it is fine crossing is effected by the agency of humble-bees. Hermann Müller observed that, from the first, the stigma usually projects a little beyond the stamens; and it is only in individual flowers that the pollen surrounds the stigma so that automatic self-pollination takes place.

Visitors.—These are undoubtedly humble-bees, but the species which actually effect cross-pollination have not, so far, been determined.

219. Oxytropis DC.

Nectar-yielding bee flowers, mostly yellow or violet in colour; with a simple valvular arrangement.

722. O. uralensis DC. (=O. Halleri *Bunge*). (Herm. Müller, 'Alpenblumen,' pp. 232–4.)—A humble-bee which forced the vexillum and alae as far as possible apart with its head would require a proboscis at least 10 mm. long to reach the nectar in this species. As the stigma projects but little beyond the anthers, it gets covered with their pollen, but does not appear to become receptive till a later stage.

VISITORS.—Herm. Müller saw Bombus mendax *Gerst.* ♀ and ☿, skg.

723. O. Gaudini Reut.—Kirchner ('Beiträge,' p. 44) says that plants of this species growing at Zermatt have the same flower mechanism as O. uralensis, but the calyx-tube is only 4 mm. long, so that even short-tongued bees can reach the nectar.

724. O. montana DC. (Herm. Müller, 'Alpenblumen,' p. 234.)—In order to reach the nectar of this species a proboscis 8–9 mm. long is necessary: otherwise the flower mechanism agrees with that of O. uralensis.

VISITORS.—Herm. Müller observed a humble-bee and 2 Lepidoptera.

725. O. lapponica Gaud. (Herm. Müller, 'Alpenblumen,' pp. 234–5.)—As in this species the calyx only surrounds the petals for a distance of 3 mm., the nectar is more readily accessible than in O. montana, with which the flower mechanism otherwise agrees.

VISITORS.—Herm. Müller only saw Lepidoptera, 2 butterflies and a Zygaena, the latter probably effecting cross-pollination. Lindman observed humble-bees paying short visits on the Dovrefjeld.

726. O. campestris DC. (Herm. Müller, 'Alpenblumen,' pp. 235–6.)—In this species the calyx-tube is 7–8 mm. long and 3–4 mm. broad. It ensheaths the claws of the petals so closely that a proboscis 11–13 mm. in length is required to reach the nectar. The vexillum possesses a nectar-guide, and the carina a pollen-guide. In other respects the flower mechanism agrees with those of O. uralensis and other species.

In the Alps the calyx is often perforated by Bombus mastrucatus 5 mm. above its base. Forficula also gnaws through the flowers.

VISITORS.—Herm. Müller observed humble-bees (5) skg. and po-cltg., and Lepidoptera (10), skg., as invited guests. Loew noticed in the Alps ('Beiträge,' p. 62) a humble-bee, Bombus pomorum *Pz.*, var. elegans *Seidl.* ☿, skg., and a butterfly, Argynnis pales *S. V.*

Ekstam says that in Nova Zemlia the tolerably odorous flowers are visited by Bombus hyperboreus *Schönh.* and B. nivalis *Dahlb.*; and also by moderately large flies.

727. O. pilosa DC. (Herm. Müller, 'Weit. Beob.,' II, pp. 253–4; Loew, Flora, Marburg, lxxiv, 1891, pp. 84–91, 'Blütenbiol. Floristik,' pp. 220, 339; Schulz, 'Beiträge,' II, p. 269.)—In the flowers of this species observed by Hermann Müller in Thuringia, the calyx ensheaths the petals for a distance of 6 mm. The vexillum

is folded together in the median plane. This fold, with the projecting tip of the carina, guides the proboscis of bee visitors, which must be 6–7 mm. long to get at the nectar. In this species too the stigma is surrounded by the pollen of its own flower, but probably this does not adhere to it without pressure.

Loew has studied this species in the Uckermark, and compared it with those described by Hermann Müller ('Alpenblumen,' pp. 232–6), i.e. O. uralensis *DC.*, O. montana *DC.*, O. lapponica *Gaud.*, and O. campestris *DC.* He describes it as intermediate between O. uralensis and O. campestris on the one hand, and O. lapponica on the other hand; for a proboscis 10–13 mm. long is requisite for securing the nectar of the first two species, while one 4–5 mm. long is necessary in the case of O. lapponica. O. montana requires a proboscis 8–9 mm. in length.

The very prominent tip of the carina, and the double union between alae and carina are specially characteristic of O. pilosa. The carina, in accordance with the mechanical arrangements of papilionaceous flowers, is exposed to the greatest pressure and pulling-strain during insect-visits. Loew says that those parts of it most liable to these stresses are best provided with epidermal cells of specifically mechanical nature, the walls of these being either wavy or strongly ribbed.

It must be added that the outer walls of the epidermal cells covering the folds of the double basal union between carina and alae are strongly papillose, while increased firmness is given by cuticular ridges radiating from the tips of the individual cells.

VISITORS.—Loew observed long-tongued dasygastrid bees in the Uckermark.—Eucera longicornis *L.* ♀ and ♂, and Osmia aurulenta *Pz.* ♀; also some Scopulipedes (humble-bees). In Thuringia Herm. Müller saw the honey-bee, skg., and Pieris rapae *L.*, do. Schulz noticed flowers perforated by humble-bees.

220. **Astragalus** *Tourn.*

Nectar-yielding bee flowers, mostly yellowish or violet in colour; with simple valvular arrangement.

728. A. Glycyphyllos L. (Herm. Müller, 'Weit. Beob.,' II, pp. 252–3; Heinsius, *Bot. Jaarb. Dodonaea, Ghent, iv, 1892, pp. 87–91*; Schulz, 'Beiträge,' II, p. 209; Knuth, 'Bloemenbiol. Bijdragen.')—The flowers of this species are greenish-yellow in colour. Hermann Müller states that the edges of the carina are so close together in the front part containing the anthers, that they scrape off some of the pollen and leave it outside when the depressed carina moves up again. The alae only interlock with the anterior part of the carina; the lower edges of their finger-like processes, which are broad and flat, abut closely on the sexual column. Only the upper half of the flower is ensheathed by the broad base of the vexillum, which passes gradually into its erect portion. Along the middle of this is a deep groove serving as a guide for the proboscis of bees. An open cleft remains between the claws of the carina and alae through which the honey-bee is in the habit of stealing nectar from the side.

VISITORS.—Humble-bees and other long-tongued bees suck the nectar legitimately and are effective visitors. Schulz also observed flowers perforated by humble-bees.

Hermann Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) observed the following in North and Central Germany.—

A. Hymenoptera. *Apidae*: 1. Apis mellifica *L.* ☿, skg. (H. M.); 2. Bombus agrorum *F.* ♀, in large numbers, skg. (H. M., Budd., Kn.); 3. B. hortorum *L.* ♀ ☿ and ♂, in large numbers, skg. legitimately (H. M.); 4. B. lapidarius *L.* ☿, skg. (H. M.); 5. B. rajellus *K.* ♀, po-cltg. and skg. legitimately (H. M.); 6. B. variabilis *Schmiedekn.*, var. tristis *Seidl.* ☿, skg. (H. M.). **B. Lepidoptera.** (*a*) *Geometridae*: 7. Odezia chaerophyllata *L.* (H. M.). (*b*) *Rhopalocera*: Melanargia galatea *L.*, skg. (H. M.).

Loew saw 2 bees in the Berlin Botanic Garden.—1. Megachile willughbiella *K.* ♂, skg.; 2. Osmia rufa *L.* ♀, po-cltg.

729. **A. aristatus** L'Hérit.—According to Briquet ('Études de biol. flor. dans les Alpes occident.'), the flowers of this species secrete abundant nectar, and are therefore eagerly visited by bees and humble-bees. They possess an explosive mechanism that acts only once, though the alae and carina subsequently return to their original position, and during subsequent visits the sexual organs protrude, as a result of elasticity. Automatic self-pollination may take place (Kirchner).

730. **A. Cicer** L.—The flowers of this species are yellowish-white in colour and possess an agreeable odour. Kirchner states that their mechanism essentially resembles that of A. Glycyphyllos.

Visitors.—Loew saw a humble-bee, Bombus agrorum *F.* ☿, skg., in the Berlin Botanic Garden.

Schulz ('Beiträge,' II, p. 209) observed flowers perforated by humble-bees.

731. **A. danicus** Retz. (=A. hypoglottis *L.*).—

Visitors.—Schulz (loc. cit.) noticed flowers perforated by humble-bees.

732. **A. exscapus** L.—Automatic self-pollination is inevitable in this species, should insect-visits fail, for the stigma lies between the anthers (Schulz).

Visitors.—Two humble-bees, Bombus hortorum *L.* and B. agrorum *F.*, skg. legitimately and effecting cross-pollination. B. terrester *L.* perforates the flowers (Schulz, loc. cit.).

733. **A. depressus** L. (Herm. Müller, 'Alpenblumen,' pp. 230–1.)—In the flowers of this species, the depressed carina very often fails to completely regain its old position, so that the stigma and stamens remain protruding from it more or less. Automatic self-pollination takes place if insect-visits fail (cf. Fig. 100).

Visitors.—Herm. Müller observed 2 humble-bees and a moth (Plusia).

734. **A. monspessulanus** L.—Hermann Müller's idea ('Alpenblumen,' p. 231), that the flowers of this species, conspicuous on account of their size and purple colour, receive a greater number of visits from humble-bees than those of A. depressus, is confirmed by MacLeod. He observed four species of humble-bee, sucking legitimately in the Pyrenees. Müller himself only saw Vanessa cardui *L.*, sucking diligently and persistently.

Visitors.—Loew noticed 2 bees in the Berlin Botanic Garden.—1. Andrena dorsata *K.* ♀, po-cltg.; 2. Bombus agrorum *F.* ♀, skg. And *vide supra*.

735. **A. alpinus** L. (=Phaca astragalina *DC.*). (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 17; Herm. Müller, 'Alpenblumen,' pp. 231–2; Lindman,

'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Loew, 'Blütenbiol. Floristik,' p. 400.)—A proboscis 6 mm. in length is sufficient to reach the nectar of this species, but bees of the kind appear to be wanting in the Alps. The agents of pollination are humble-bees and other long-tongued bees, as well as numerous Lepidoptera.

VISITORS.—Herm. Müller observed Bombus alticola *Kriechb.* ☿, skg. and po-cltg., and also 6 Lepidoptera. Loew saw Bombus mastrucatus *Gerst.* ☿, skg., and Osmia morawitzi *Gerst.* ♂, do., in the Alps (Albula). Lindman noticed humble-bees and Lepidoptera on the Dovrefjeld.

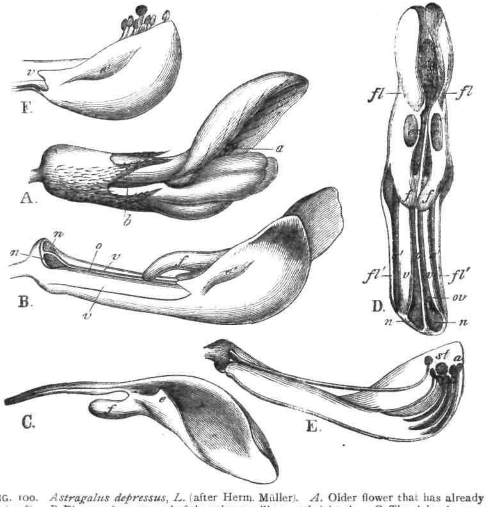


FIG. 100. *Astragalus depressus*, *L.* (after Herm. Müller). *A.* Older flower that has already been visited (×4⅔). *B.* Flower after removal of the calyx, vexillum, and right ala. *C.* The right ala, seen from the inner side. *D.* Flower after removal of calyx and vexillum, seen from above. *E.* Carina after removal of its right side. *F.* Anterior portion of the carina, depressed. (*B–F*×7.) *a*, anthers; *b* and *v*, staminal tube; *e*, alar fold (seen from inside); *e'*, do. (seen from outside); *f*, alar lappet; *fl fl'*, alae; *n*, nectaries; *o*, upper filament; *ov*, ovary; *s s' sch*, parts of carina; *st*, stigma.

Schneider observed the following humble-bees in Arctic Norway (Mus. Aarsh. Tromsø, xvii, 1895):—1. Bombus alpinus *L.* ♀ and ☿; 2. B. hyperboraeus *Schönh.* ♀; 3. B. hypnorum *L.* ♀ and ☿; 4. B. lapponicus *L.* ♀ and ☿; 5. B. scrimshiranus *K.* ♀ and ☿; 6. B. terrester *L.* ♀ and ☿.

Ekstam saw small humble-bees visiting the fragrant flowers in Nova Zemlia.

736. A. oroboides Hornem.—Axell describes (op. cit., p. 17) the flowers of this species as homogamous, and says that their mechanism agrees with that of A. alpinus. They are pale blue, passing into violet at the bases of the vexillum and carina, and markedly asymmetrical.

Visitors.—Lindman says that the flowers are sparingly visited on the Dovrefjeld by humble-bees and Lepidoptera.

737. A. alopecuroides L.—

Visitors.—Loew saw Bombus hortorum *L.* ♀ and ☿, steadily skg., in the Berlin Botanic Garden.

738. A. arenarius L.—

Visitors.—Bombus pratorum *L.* ☿, skg. (Loew, Berlin).

739. A. glycyphylloides DC.—

Visitors.—Bombus agrorum *F.* ♀, skg. (Loew, Berlin).

740. A. narbonensis Gouan.—

Visitors.—Bombus hortorum *L.* ☿, skg., and Megachile fasciata *Sm.* ♂, do. (Loew, Berlin).

741. A. onobrychis L.—

Visitors.—Megachile fasciata *Sm.* ♂, skg. (Loew, Berlin). Von Dalla Torre and Schletterer record the following bees for the Tyrol.—

1. Andrena curvungula *Thoms.*; 2. Bombus confusus *Schenck*; 3. B. hortorum *L.*; 4. B. variabilis *Schmiedekn.*; 5. Eucera longicornis *L.*; 6. Megachile muraria *L.*; 7. Melecta luctuosa *Scop.*; 8. Osmia aurulenta *Pz.*; 9. O. cornuta *Ltr.*; 10. O. spinolae *Schenck*; 11. Podalirius fulvitarsis *Lep.*; 12. P. parietinus *F.*; 13. P. retusus *L.*; 14. Sphecodes similis *Wesm.*

Schulz observed flowers perforated by humble-bees at Bozen.

221. Coronilla L.

Yellow nectarless bee flowers, with pumping arrangement, from which threads of pollen are extruded.

742. C. vaginalis Lam. (=C. montana *Schr.*). (Herm. Müller, 'Alpenblumen,' pp. 249–52.)—The flower mechanism of this species agrees on the whole with that of Lotus. There are differences, however, in the order of development of the inner and outer filaments, and as to the part they play in pressing out pollen; also as regards the relative size of the alae and carina and the way they are united together. The carina too is less easily depressed. It is doubtful if self-pollination takes place (cf. Fig. 101).

Visitors.—These are very rare. In good weather, and after watching for days, Herm. Müller only once observed a po-cltg. bee (Andrena ?).

743. C. varia L. (Delpino, 'Ult. oss.,' p. 45; Herm. Müller, 'Fertilisation,' pp. 198–9; Kirchner, 'Flora v. Stuttgart,' p. 498; Loew, 'Blütenbiol. Floristik,' p. 399.)—In this species, again, the flower mechanism is similar to that of Lotus, except that the thickened ends of all ten filaments act as pistons. The two openings at the base of the free filament are wanting, for the flowers do not secrete nectar in the usual place, but on the outside of the fleshy calyx, where it is sought out by bees. These settle upon the alae in the normal fashion, and probe beneath the vexillum. The proboscis passes through the wide space between the unusually slender bases of the petals to the outside of the flower, encountering the nectar on the calyx (Kirchner).

VISITORS.—Herm. Müller noticed the honey-bee in Thuringia. Loew saw a bee (Andrena propinqua *Schenck* ♀) po-cltg. in the Alps; and, in Silesia, a butterfly (Hesperia comma *L.*) vainly trying to suck. He also observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*, settling on the corolla. **B. Hymenoptera.** *Apidae*: 2. Anthidium manicatum *L.* ♀, po-cltg., and trying to suck; 3. Bombus agrorum *F.* ☿, vainly skg.; 4. B. hortorum *L.* ☿, po-cltg.; 5. B. lapidarius *L.* ☿, po-cltg. and vainly skg.; 6. B. rajellus *K.* ☿, skg.; 7. Megachile centuncularis *L.* ♀, po-cltg. and vainly skg.; 8. M. fasciata *Sm.* ♀, do.; 9. M. lagopoda *L.* ♀, po-cltg.; 10. Osmia aenea *L.* ♀, do.

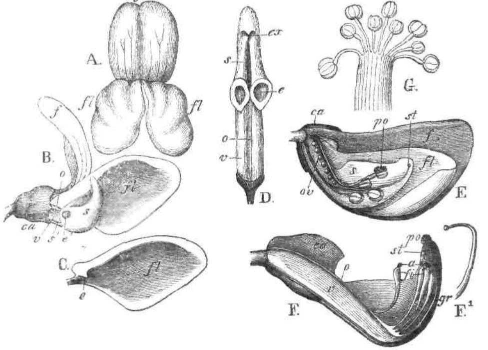


FIG. 101. *Coronilla vaginalis*, *Lam.* (after Herm. Müller). *A.* Flower seen from the front (× 3½). *B.* The same, after removal of the right half of the vexillum, and of the right ala. *C.* Left ala seen from the inside (× 3½). *D.* Flower after removal of calyx, vexillum, and alae; seen from above (× 7). *E.* Young bud in longitudinal sections. *F.* Calyx and carina with enclosed stamens and pistil (in section). *F'.* Style and stigma. *G.* The nine united stamens, removed from a bud and spread out. *a*, anthers; *ca*, calyx; *e*, alar process, fitting into carinal pit (*e'*); *ex*, tip of carina; *f*, vexillum; *fi*, filaments; *fl*, alae; *gr*, style; *o*, posterior filament; *ov*, ovules; *po*, pollen; *s*, carina; *s'*, carinal claw; *st*, stigma; *v*, staminal tube.

Rössler saw the butterfly Lycaena argus *L.* at Wiesbaden. Schletterer noticed the mason-bee Megachile (Chalicodoma) muraria *Retz.* in the Tyrol; and, at Pola, the rare Xylocopa cyanescens *Brull.*, which is the smallest European carpenter-bee.

744. C. montana Scop., **745. C. glauca** L., and **746. C. minima** L.—These species, according to Farrer (Nature, London, x, 1874), agree with C. varia as regards the flower mechanism and secretion of nectar.

VISITORS.—For C. montana Loew observed a humble-bee (Bombus rajellus *K.* ☿), po-cltg., in the Berlin Botanic Garden.

747. C. Emerus L.—It was in this species that Delpino ('Ult. oss.,' pp. 39–44) first recognized and described in detail the pump arrangement by which threads of pollen are extruded ('apparecchio che offre una curiosa analogia col meccanismo con cui si fabbrica la pasta da vermicellajo').

VISITORS.—Delpino noticed long-tongued bees:—Bombus, Eucera longicornis *L.*, Anthophora pilipes *F.*, and Xylocopa violacea *L.* Friese saw the beautiful bee Podalirius tarsatus *Spin.*, freq., at Bozen. Ducke, at Trieste, observed the bees Eucera caspica *Mor.* ♀ and ♂, and Megachile (Chalicodoma) manicata *Gir.* ♀ and ♂. Schletterer records the following bees for Pola.—

1. Andrena carbonaria *L.*; 2. A. flavipes *Pz.*; 3. A. parvula *K.*; 4. Eucera interrupta *Baer.*; 5. Halictus patellatus *Mor.*; 6. H. sexcinctus *F.*; 7. Podalirius tarsatus *Spin.* (also in the Tyrol).

222. Ornithopus L.

Bee flowers with simple valvular arrangement.

748. O. perpusillus L. (Herm. Müller, 'Weit. Beob.,' II, pp. 262–3; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 62.)—In the diminutive yellowish flowers of this species, the vexillum is streaked with purple. The bases of the petals and stamens are fused with the calyx. Hermann Müller supposed this fusion to indicate that in favourable weather the base of the flower would be quite full of nectar, but on examination found none at all. Nor was I able to detect any in numerous flowers examined in the island of Föhr. The stamens and pistil mature simultaneously, and are of equal length. Despite careful watching I observed no visitors, yet fruits are regularly set, so that automatic self-pollination is undoubtedly effective.

VISITORS.—Herm. Müller, in Westphalia, observed only one diminutive bee (Halictus flavipes *F.* ♀), skg. and po-cltg., and a minute digging-wasp (Passaloecus turionum *Dahlb.* ♂), skg.?

MacLeod saw Bombus agrorum *F.* ♀, skg.?, in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 354).

A hover-fly has been recorded for Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 48).

749. O. sativus *Brot.* (*Kirchner, 'Beiträge,' pp. 44–5; Knuth, 'Bloemenbiol. Bijdragen.'*)—In cultivated plants of this species, Kirchner described the flower mechanism as follows.—The calyx is about 5 mm. in length, and its tube $2\frac{1}{2}$ mm. The erect lamina of the vexillum, which projects from it, is 7–8 mm. long, and rose-coloured with dark veins. The alar laminae are of a brighter hue, about 6 mm. long, and with a deep longitudinal fold running parallel to their upper margin. These folds overlie the carina and staminal tube in such a way as to be in continuous contact with them. The alae also possess rounded elastic processes, directed backwards. At the posterior end of each alar lamina its process firmly interlocks with a dorso-lateral carinal pit. Carina and alae are therefore intimately united in this region. The spheroidal stigma is closely surrounded by the mature anthers, both projecting together from the greenish carina (only 1 mm. long) when the alae are depressed. They return into the carina when the pressure is removed.

Although a moderately large aperture on either side the base of the upper free filament leads into the staminal tube, Kirchner found no nectar even in sunny weather; nor could I detect any. Kirchner thinks secretion possibly takes place only under particularly favourable circumstances, or in the native habitat of the species in the South.

The flower is slightly asymmetrical, the vexillum being twisted a little to the right at its base, and the left ala to the left. Of the two longitudinal alar folds, that on the left is the deeper. The right ala is nearly perpendicular, or curved somewhat to the left. The front ends of the filaments are also somewhat twisted to the left.

Stigma and anthers being close together, automatic self-pollination is inevitable. Cross-pollination can be effected by insects.

VISITORS.—Kirchner (Wurtemburg) and myself (Schleswig-Holstein) have observed the honey-bee. It introduces its proboscis normally as if about to suck, and therefore possibly bores for sap in the base of the flower. Kirchner also saw Meligethes. MacLeod noticed Apis and Eristalis tenax *L.* in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 380).

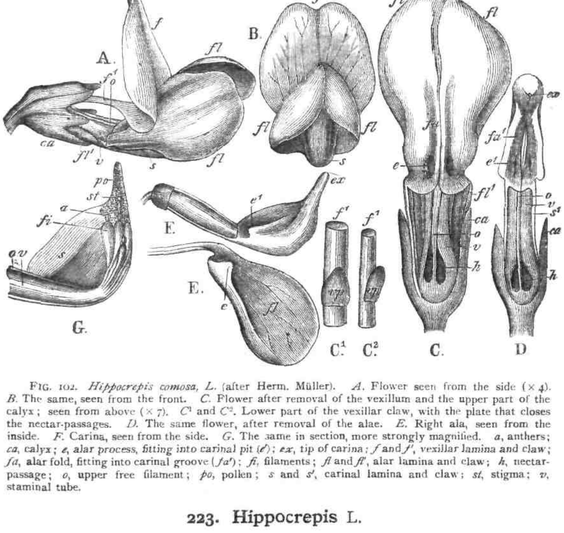


FIG. 102. *Hippocrepis comosa, L.* (after Herm. Müller). *A.* Flower seen from the side (× 4). *B.* The same, seen from the front. *C.* Flower after removal of the vexillum and the upper part of the calyx; seen from above (× 7). C^1 and C^2. Lower part of the vexillar claw, with the plate that closes the nectar-passages. *D.* The same flower, after removal of the alae. *E.* Right ala, seen from the inside. *F.* Carina, seen from the side. *G.* The same in section, more strongly magnified. *a*, anthers; *ca*, calyx; *e*, alar process, fitting into carinal pit (*e'*); *ex*, tip of carina; *f* and *f'*, vexillar lamina and claw; *fa*, alar fold, fitting into carinal groove (*fa'*); *fi*, filaments; *fl* and *fl'*, alar lamina and claw; *h*, nectar-passage; *o*, upper free filament; *po*, pollen; *s* and *s'*, carinal lamina and claw; *st*, stigma; *v*, staminal tube.

223. **Hippocrepis** L.

Yellow nectar-yielding bee flowers, with pumping arrangement extruding threads of pollen.

750. H. comosa L. (Herm. Müller, 'Alpenblumen,' pp. 252–4.)—Hermann Müller says that the flower mechanism agrees essentially with that of Lotus. The union of alae and carina, however, is much firmer, for each of the former possesses a fold and a deep saccular process, which fit into corresponding carinal depressions.

The nectar is also concealed in a remarkable way, for the claw of the vexillum is so slender and bends so far upwards out of the short calyx, that it is possible to look into the flower laterally between it and the stamens. It would, therefore, appear as if insect visitors could easily steal nectar from the side, without setting the flower mechanism in motion. This, however, is not the case, for the claw of the vexillum bears a projecting triangular plate on the under-side of its base, and by this the two nectar-passages are completely closed. Insects can only remove this obstruction by thrusting in their heads under the vexillum (cf. Fig. 102).

VISITORS.—Herm. Müller chiefly observed bees (12) and Lepidoptera (9) in the Alps. Schulz noticed flowers perforated by humble-bees in Central Germany.

Schmiedeknecht saw 3 bees in Thuringia:—1. Osmia aurulenta *Pz.*; 2. O. uncinata *Gerst.*; 3. O. xanthomelaena *K.* (=O. fuciformis *Gerst.*).

Friese observed the following bees in Baden (B.), Hungary (H.), Switzerland (S.), Thuringia (T.), and Trieste (Tr.).—

1. Megachile muraria *Retz.* (B.); 2. Osmia acuticornis *Duf. et Perr.* ♂ (H.); 3. O. andrenoides *Spin.*, infrequent; 4. O. aurulenta *Pz.*, freq. (B.); 5. O. gallarum *Spin.*, not infrequent (H., Tr.); 6. O. lepeletieri *Pér.*; 7. O. leucomelaena *K.*, freq. (H., Tr.); 8. O. rufohirta *Lep.* ♀ and ♂, skg. (H., T.); 9. O. uncinata *Gerst.* (S., T.); 10. O. xanthomelaena *K.* (T., S.).

Loew saw Apis mellifica *L.* ☿, po-cltg., in Hesse, and, skg., in the Berlin Botanic Garden, where he also noticed a humble-bee (Bombus lapidarius *L.* ☿), do. ('Beiträge,' p. 53).

Ducke observed the following *Apidae* at Trieste.—

1. Eucera cinerea *Lep.* ♀ and ♂; 2. Megachile (Chalicodoma) pyrenaica *Lep.*; 3. Osmia andrenoides *Spin.* ♀ and ♂, freq.; 4. O. campanularis *Mor.* ♂; 5. O. giraudi *Schmiedekn.*, not very infrequent; 6. O. fulviventris *Pz.* ♂, not infrequent; 7. O. jheringi *Ducke* ♀ and ♂, very freq.; 8. O. longiceps *Mor.* ♀ and ♂, not infrequent; 9. O. pallicornis *Friese* ♀ and ♂, freq.; 10. O. rubicola *Friese* ♀, freq., ♂, very occasional; 11. O. rufohirta *Ltr.* ♀, freq., ♂, rather rare; 12. O. solskyi *Mor.*, rather rare; 13. O. tergestensis *Ducke* ♀ and ♂, infrequent; 14. O. tiflensis *Mor.* ♀ and ♂, occasional; 15. O. tridentata *Duf. et Perr.*, rare.

MacLeod noticed 2 long-tongued bees and a Lepidopterid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 440).

224. Desmodium Desv.

751. D. canadense DC.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Melithreptus scriptus *L.*, settling. **B. Hymenoptera.** *Apidae*: 2. Megachile centuncularis *L.* ♀, po-cltg.; 3. M. fasciata *Sm.*, ♀, do. **C. Lepidoptera.** *Rhopalocera*: 4. Pieris brassicae *L.*, skg.

225. Hedysarum L.

Red nectar-yielding bee flowers, with simple valvular arrangement.

752. H. obscurum L. (Herm. Müller, 'Alpenblumen,' pp. 254–5; Schulz, 'Beiträge,' I, p. 32, II, p. 210.)—Hermann Müller says that for this species a proboscis 9–10 mm. long is required to suck legitimately. The flower mechanism is the simplest in the sub-order. When a humble-bee visits a flower, the stigma

and anthers protrude from the carina, pressing against its ventral surface. As the stigma projects about 2 mm. beyond the anthers, it is the first to emerge, so that cross-pollination is assured, and self-pollination rendered difficult.

VISITORS.—Herm. Müller chiefly observed skg. or po-cltg. humble-bees (5), and skg. Lepidoptera (13), which usually effected cross-pollination. Bombus mastrucatus *Gerst.* also obtained nectar by perforating the flowers.

In the Riesengebirge, A. Schulz noticed humble-bees, and also flowers perforated by them.

Loew saw the following bees in the Berlin Botanic Garden.—1. Apis mellifica *L.* ☿, skg.; 2. Bombus hortorum *L.* ♀, do.; 3. B. lapidarius *L.* ☿, do.; 4. Osmia rufa *L.* ♀, skg. and po-cltg.

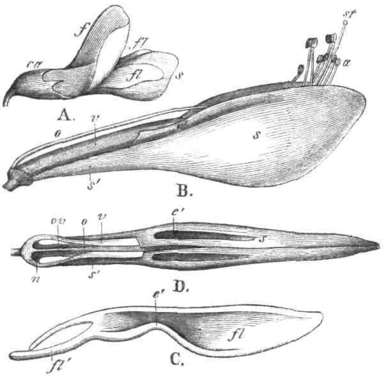


FIG. 103. *Hedysarum obscurum*, *L.* (after Herm. Müller). *A.* Flower seen from the side (× 1½). *B.* Flower after removal of calyx, vexillum, and alae, and depression of the carina, seen from the side. *D.* The same seen from above. *C.* Right ala from the inside (*B–D* × 3½). *a*, anthers; *ca*, calyx; *e'*, alar fold; *f*, vexillum; *fl* and *fl'*, alar lamina and claw; *n*, nectar-passage; *o*, free upper filament; *ov*, ovary; *s* and *s'*, carinal lamina and claw; *v*, staminal tube.

753. H. sibiricum Poir.—

VISITORS. — Loew observed 2 humble-bees (Bombus agrorum *F.* ☿, and B. rajellus *K.* ♀) skg., in the Berlin Botanic Garden.

754. H. coronarium L.—This is an Italian species.

VISITORS. — Von Dalla Torre saw 3 bees in the Innsbruck Botanic Garden.—1. Megachile ericetorum *Lep.* ♂, effecting pollination; 2. Halictus leucozonius *K.*, var. nigrotibialis *D.-T.*, do.; 3. Megachile maritima *K.* ♂, freq.

Schletterer records the same for the Tyrol.

226. **Onobrychis** Tourn.

Red nectar-yielding bee flowers, with simple valvular arrangement.

755. O. viciaefolia Scop. (=O. sativa *Lam.*). (Herm. Müller, 'Fertilisation,' pp. 200–1, 'Weit. Beob.,' II, *p.* 263; Schulz, 'Beiträge'; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller says that the flower mechanism of this species agrees essentially with those of Melilotus and Trifolium. The stigma and anthers protrude from the carina when this is weighed down by an insect visitor, resuming their original position as soon as the pressure is removed. The vexillum is rose-red with darker streaks, and the carina of a brighter red. The alae are greatly reduced,

covering only the claws of the carina, and serving as nectar-covers, by which lateral access is prevented or at least rendered difficult. The platform for insect visitors is therefore constituted by the carina alone. As the result of its own elasticity, this returns to its original position on the conclusion of a visit. The stigma projects beyond the anthers, so that cross-pollination is ensured should such visits take place. Automatic self-pollination is excluded, especially as the style becomes more and more erect as anthesis progresses, and ultimately projects 1–1½ mm. from the carinal cleft. Since the calyx-tube is only 2–3 mm. long, the nectar and pollen are accessible, even to the shortest-tongued bees. Schulz noticed flowers perforated by humble-bees in Central Germany.

Visitors.—Herm. Müller says that the honey-bee (skg. and po-cltg.) is by far the most frequent guest, paying at least nine-tenths of all the visits. I myself noticed it in great numbers in Mecklenburg. Herm. Müller also records the following.—

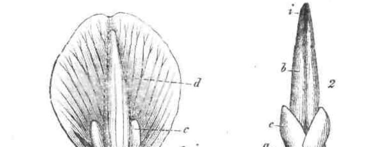


FIG. 104. *Onobrychis viciaefolia*, Scop. (after Herm. Müller). (1) Flower from below (× 3). (2) The same, after removal of the vexillum and upper half of the calyx; from above. (3) Stamens and pistil, from the side (× 7). *a*, calyx; *b*, carina; *c*, ala; *d*, vexillum; *e*, alar claw; *f*, united filaments; *g*, free filament; *h*, nectar-passage; *i*, cleft in the carina, through which stamens and stigma protrude.

A. Hymenoptera. *Apidae*: 1. Anthidium manicatum *L.* ♀, skg. and po-cltg., ♂, skg.; 2. Andrena labialis *K.*, do.; 3. A. nigroaenea *K.* ♂; 4. Apis mellifica *L.* ☿, skg.; 5. Bombus agrorum *F.* ♀ and ☿, skg. and po-cltg.; 6. B. confusus *Schenck* ♀, do.; 7. B. muscorum *F.* ♀, do.; 8. B. pratorum *L.* ♀ and ☿, do.; 9. B. scrimshiranus *K.* ♀, do.; 10. B. sylvarum *L.* ♀, do.; 11. B. terrester *L.* ♀, do.; 12. Chalicodoma muraria *F.* ♀, do. (Thuringia); 13. Coelioxys conoidea *Ill.* ♀, skg.; 14. C. umbrina *Sm.* ♂, in large numbers, skg.; 15. Eucera longicornis *L.* ♀ and ♂, skg. and po-cltg.; 16. Halictus albipes *F.* ♀, do.; 17. H. flavipes *F.* ♀, do.; 18. H. lugubris *K.* ♀; 19. Megachile argentata *F.* ♂, skg.; 20. M. centuncularis *L.* ♂, do.; 21. M. circumcincta *K.* ♀, skg. and po-cltg.; 22. M. fasciata *Sm.* ♂, skg.; 23. M. willughbiella *K.* ♀, skg. and po-cltg., ♂, skg.; 24. Osmia aenea *L.* ⚥, freq., skg. and po-cltg.; 25. O. aurulenta *Pz.* ♀, skg. and po-cltg. (Thuringia); 26. O. fulviventris *Pz.* ♀, in large numbers, skg. and po-cltg.; 27. O. rufa *L.* ♀, skg.; 28. O. spinulosa *K.* ♀, do. (Thuringia); 29. Psithyrus campestris *Pz.* ♀, do.; 30. P. rupestris *F.* ♀, do.; 31. Xylocopa violacea *L.* ♂, do. **B. Diptera.** *Syrphidae*: 32. Volucella bombylans *L.*, var. plumata *Mg.* **C. Lepidoptera.** (*a*) *Noctuidae*: 33. Euclidia glyphica *L.*, freq., skg., but apparently not effecting pollination; 34. Plusia gamma *L.* do. (*b*) *Rhopalocera*: 35. Lycaena aegon *S. V.* ♂, skg.; 36. L. corydon *Poda.*, do.; 37. L. icarus *Rott.*, do.; 38. L. sp., freq., skg., but apparently not effecting pollination; 39. Pieris napi *L.*, skg.; 40. Thecla ilicis *Esp.*, do. (*c*) *Sphingidae*: 41. Zygaena carniolica *Scop.*, freq., skg., but apparently not effecting pollination (Thuringia).

Herm. Müller also saw 4 bees in the Alps ('Alpenblumen,' p. 254).

Loew noticed 5 bees in the Berlin Botanic Garden:—1. Anthidium manicatum *L.* ♀, skg. and po-cltg.; 2. Bombus agrorum *F.* ♀, skg.; 3. B. lapidarius *L.* ☿, do.; 4. Megachile fasciata *Sm.* ♂, do.; 5. Osmia aenea *L.* ♀, po-cltg.

Schletterer records a bee (Meliturga clavicornis *Ltr.*) for the Tyrol.

Rössler observed a moth (Grapholitha caecana *Schl.*) at Wiesbaden. Ducke records the following bees.—

1. Anthidium cingulatum *Ltr.* ♀ and ♂; 2. Melitta dimidiata *Mor.*; 3. Osmia rubicola *Friese* ♀, freq., ♂, occasional; 4. O. rufohirta *Ltr.* ♀, freq.; 5. O. tergestensis *Ducke* ♀ and ♂; 6. O. tiflensis *Mor.* ♀, occasional; 7. O. versicolor *Ltr.* ♀ and ♂, very freq.

756. **O. aurea** Stev.—

Visitors.—Loew saw a bee (Osmia aenea *L.* ♀), skg. and po-cltg., in the Berlin Botanic Garden.

757. **O. montana** DC.—

Visitors.—Two bees:—Anthidium manicatum *L.* ♀, skg. and po-cltg., Megachile fasciata *Sm.* ♂, skg. (Loew, Berlin).

758. **O. arenaria** DC.—

Visitors.—A humble-bee, Bombus rajellus *K.* ☿, skg. (Loew, Berlin). Friese (on the authority of Mocsary) gives the bee Nomia femoralis *Pall.*, freq., for Hungary.

227. **Vicia** Tourn.

Nectar-yielding bee flowers, with a stylar brush.

In many species of this genus there are extra-floral nectaries. These are deeply coloured spots situated on the under-side of the stipules. They secrete nectar in sunny but not in dull weather. The secretion is eagerly sought out by ants, which for their part serve to protect the plants against caterpillars and the like.

759. **V. Cracca** L. (Delpino, 'Ult. oss.,' p. 58; Herm. Müller, 'Fertilisation,' pp. 202–4, 'Weit. Beob.,' II, p. 262; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892, p. 100; MacLeod, op. cit., vi, 1894, pp. 354–6; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen'; Loew, 'Blütenbiol. Statistik,' p. 400.)—The purple flowers of this species are arranged in crowded racemes. The flower mechanism was first described by Delpino, and subsequently in greater detail by Hermann Müller. Each ala is united with the carina at two places. About the middle of its upper margin there is a hollow process, small but deep, which fits closely into a pit in the upper surface of the carina. Immediately behind this is a second alar process, much broader but equally deep. It is connected with a broad, but rather shallow depression in the upper surface of the carina, the epidermal cells of the two petals being so firmly interlocked that it is difficult to separate without at the same time tearing them. On the back of the vexillum, at the bend between claw and lamina, there are two grooves diverging anteriorly; these project below as ridges which are applied to the alae so as to block up the lateral passages to the nectar.

When a bee visits the flower it settles on the alae, and these, being firmly united with the carina as above described, act like the long arm of a lever and cause its depression. The carina and alae return to their original position after the insect visitor has departed. This is partly due to their elasticity, and partly because the upper basal corners of the alae are produced into backwardly and inwardly directed processes, which lie upon the upper surface of the sexual column. This is also grasped by the two upper basal lobes of the carina, between which only a narrow space is left. And lastly, the broad base of the vexillum curves so far forwards on each side that it completely surrounds the claws of the alae and carina. More than half the length of the extremely short style (only about $1\frac{1}{2}$ mm. in length), is beset with hairs from immediately below the terminal stigma downwards. These are longer and closer on the outer than on the inner side.

FIG. 105. *Vicia Cracca*, L. (after Herm. Müller). (1) Flower seen from the side (× 3). (2) The same, after removal of calyx and vexillum, seen from above (further enlarged). (3) The same, after the alae also have been removed. (4) Left ala from the inside. (5) Style (still more enlarged). *a*, anterior alar process; *a′*, corresponding carinal pit; *b*, posterior alar process; *b′*, corresponding carinal depression; *c*, backwardly and inwardly directed alar process; *d*, alar claws; *e*, carinal claws; *f*, dilatation of the carina containing pollen; *g*, upper basal lobes of the carina; *h*, nectar; *o*, opening through which the style passes out; *p*, stylar brush; *st*, stigma.

The flowers have barely reached half their full size, when the anthers, which closely surround the stylar brush, dehisce and shed their pollen among the hairs of the brush, the stigma being also covered with it. When a bee visits the flower, pollen adheres to its under-side and the stigma is at the same time rendered sticky and receptive by rupture of its papillae.

VISITORS.—These are bees and Lepidoptera, though the latter suck nectar without effecting pollination. I saw Apis, 2 Bombus, and a Zygaena on the North Frisian Islands; Bombus agrorum *F.*, skg., at Flensburg; and, in Rügen, 2 humble-bees, skg.—Bombus hortorum *L.*, and B. sylvarum, var. albicauda *Schmiedekn.*

Alfken observed the following bees at Bremen.—

1. Anthidium manicatum *L.* ♀; 2. Bombus arenicola *Ths.* ♀ and ☿; 3. B. derhamellus *K.* ☿ and ♂; 4. B. distinguendus *Mor.* ☿; 5. B. muscorum *F.* ☿; 6. B. sylvarum *L.* ♀ and ☿; 7. Coelioxys rufescens *Lep.* ♀, skg.; 8. Eucera difficilis (Duf.) *Pér.* ♀; 9. Megachile centuncularis *L.* ♀ and ♂; 10. Podalirius borealis *Mor.* ♀.

Krieger saw Eucera longicornis *L.* (once) at Leipzig. De Vries noticed numerous honey-bees, skg., in the Netherlands. Heinsius saw Zygaena filipendulae *L.*, and Lycaena icarus *Rott.* ♂ in Holland. MacLeod observed 2 long-tongued bees, and 2 Lepidoptera in Flanders; a humble-bee and a Lepidopterid in the

Pyrenees. Loew noticed Psithyrus globosus *Ev.* ♂, skg., in the Alps, and Lindman saw several humble-bees and Lepidoptera on the Dovrefjeld.

Hermann Müller gives the following list for Westphalia.—

A. Hymenoptera. (*a*) *Apidae*: 1. Apis mellifica *L.* ☿, freq., skg. (Thuringia); 2. Bombus agrorum *F.* ♀ and ☿, skg.; 3. B. hortorum *L.* ☿, do.; 4. B. rajellus *K.* ☿, do.; 5. B. scrimshiranus *K.* ♂ ♀ and ☿, do.; 6. Eucera longicornis *L.* ♀ and ♂, do.; 7. Diphysis serratulae *Pz.* ♀, skg. and po-cltg.; 8. Megachile circumcincta *K.* ♀, do.; 9. M. maritima *K.* ♀, do.; 10. M. versicolor *Sm.* ♀, do.; 11. M. willughbiella *K.* ♀, do.; 12. Osmia adunca *Ltr.* ♀, do.; 13. Psithyrus vestalis *Fourc.* ♂, do. (*b*) *Vespidae*: 14. Odynerus quadrifasciatus *F.* ♀, vainly skg. **B. Diptera.** *Empidae*: 15. Empis livida *L.*, freq., skg. **C. Lepidoptera.** (*a*) *Rhopalocera*: 16. Hesperia lineola *O.*, skg.; 17. Lycaena arion *L.*, do.; 18. Melanargia galatea *L.*, do.; 19. Pieris rapae *L.*, do., but without effecting pollination. (*b*) *Sphingidae*: 20. Zygaena meliloti *Esp.*, skg.

Herm. Müller also saw 4 Apidae and 5 Lepidoptera in the Alps ('Alpenblumen,' p. 249).

In Dumfriesshire, 2 humble-bees, an Empid, and a hover-fly were recorded (Scott-Elliot, Flora, p. 49).

760. V. hybrida L.—

Visitors.—Schletterer observed three bees at Pola:—1. Eucera interrupta *Baer.*; 2. E. longicornis *L.*; 3. Halictus interruptus *Pz.*

761. V. dumetorum L.—Kirchner ('Flora v. Stuttgart,' p. 503) describes the flower mechanism as similar to that of V. Cracca. The style is 3 mm. in length, and surrounded by hairs for a length of 1 mm. from its tip; the hairs on the outer being noticeably longer than those on the inner side. The anthers dehisce in the young bud, but the stigma is moderately well protected from the pollen of its own flower by the stylar brush. Each ala is united with the carina by a smaller anterior, and a much larger and deeper posterior process: the epidermal cells of the latter interlock.

Visitors.—These are bees. Loew observed Bombus agrorum *F.* ☿, skg., in the Berlin Botanic Garden. The honey-bee steals nectar from the side by pushing the petals apart. Schulz noticed flowers perforated by humble-bees.

762. V. villosa Roth.—Kirchner ('Flora v. Stuttgart,' p. 502) states that the flower mechanism of this species also agrees essentially with that of V. Cracca, but the anthers dehisce and shed their pollen on the stylar brush when the flowers are almost full grown.

Visitors.—Höppner saw a bee (Podalirius retusus *L.*), skg., at Bremen.

Schletterer observed the variety varia *Host.* to be visited by the following bees at Pola.—

1. Anthidium manicatum *L.*; 2. Colletes lacunatus *Dours.*; 3. Eucera alternans *Brull.*; 4. E. longicornis *L.*; 5. E. parvula *Friese*; 6. E. ruficollis *Brull.*; 7. Podalirius retusus *L.*, var. meridionalis *Pér.*; 8. P. tarsatus *Spin.* Also 9. the Mutilla viduata *Pall.*

763. V. sepium L. (Sprengel, 'Entd. Geh.,' pp. 356–7; Herm. Müller, 'Fertilisation,' pp. 204–6, 'Weit. Beob.,' II, p. 262; Schulz, 'Beiträge'; de Vries, Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875; Knuth, 'Bloemenbiol. Bijdragen'; Loew, 'Blütenbiol. Floristik,' pp. 392, 395.)—The blossoms of this species are dirty lilac in colour, with a yellowish base. Hermann Müller describes the

flower mechanism as similar to that of V. Cracca, except as regards the nature of the brush arrangement. For here the style ($2\frac{1}{2}$ mm. long) bears two brushes, immediately beneath the stigma. They are completely separate, about 1 mm. long, and respectively situated internally and externally. The inner brush consists of a single row of short hairs slanting upwards, while the outer one is composed of hairs which radiate obliquely upwards towards the stigma, and enclose a plate-like depression. The anthers dehisce when the flowers have attained a considerable size, shed their pollen into a swelling at the tip of the carina, and are then retracted.

Access to the nectar is more difficult than in V. Cracca, for the petals are thicker and firmer, the calyx-tube surrounds their claws for a greater distance, and the vexillum is tumid at the entrance to the nectar-passage, which is bounded by it and the alae. In addition to this, the arms of the alar levers, which depress

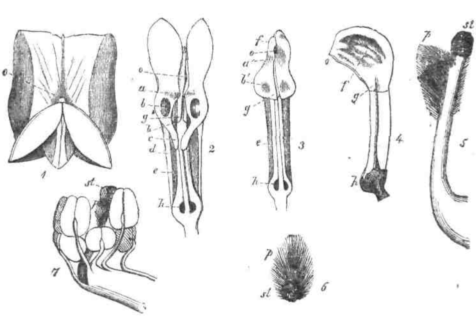


FIG. 106. *Vicia sepium, L.* (after Herm. Müller). (1) Flower seen from the front. (2) The same, after removal of calyx and vexillum; seen from above. (3) The same, after the alae also have been removed; seen from above. (4) The same, seen from the side. (5) Style with brushes and stigma, seen from the side. (6) Brushes and stigma, seen from above. (7) Stamens and pistil of a bud. References as in Fig. 105.

the carina, are relatively shorter than in V. Cracca. Hence only powerful bees (Bombus, Anthophora) are able to suck legitimately and effect crossing. The flies and Lepidoptera which so often steal nectar from V. Cracca, sucking legitimately but without benefit to its flowers, are here excluded, and this is a distinct advantage. On the other hand, Bombus terrester regularly perforates the flowers from the side and steals the nectar, although it possesses the requisite strength, skill, and length of proboscis. Nectar is stolen by feebler bees with a shorter proboscis (Apis, Osmia rufa) through the holes thus made.

VISITORS.—The following have been observed by Herm. Müller (H. M.) in Westphalia, Buddeberg (Budd.) in Nassau, and myself (Kn.) in Schleswig-Holstein.—

A. Hymenoptera. *Apidae*: 1. Anthophora aestiva *Pz.* ♂, skg. (Budd.); 2. A. pilipes *F.* ♀ and ♂, skg. legitimately (H. M.); 3. Apis mellifica *L.* ☿, using the holes made by B. *terrester L.* (H. M., Kn.); 4. Bombus agrorum *F.* ♀ and ☿, skg. (H. M., Kn.); 5. B. lapidarius *L.* ♀ and ☿, do. (H. M., Kn.); 6. B. muscorum *F.* ☿,

do. (Budd.); 7. B. rajellus *K.* ♀ and ☿, do. (H. M., Kn.); 8. B. sylvarum *L.* ♀, do. (H. M.); 9. B. terrester *L.* ☿, perforating the flowers, and stealing nectar (H. M., Kn.); 10. Eucera longicornis *L.* ☿ and ♂, skg. (Budd., Kn.); 11. Megachile circumcincta *K.* ♀, do. (Budd.); 12. Osmia aurulenta *Pz.* ♀, in large numbers, skg. (Budd.); 13. O. rufa *L.* ♀, freq., skg. (Budd.), stealing nectar through holes made by B. terrester *L.* (H. M.). **B. Diptera.** *Bombyliidae*: 14. Bombylius canescens *Mikan.*, skg. (Budd.).

Wüstnei saw Eucera longicornis *L.* in the island of Alsen.

Alfken noticed the following bees at Bremen.—

1. Andrena convexiuscula *K.* ♂; 2. A. xanthura *K.* ♀; 3. Bombus arenicola *Ths.* ♀; 4. B. derhamellus *K.* ♀; 5. B. lapidarius *L.* ♀; 6. B. muscorum *F.* ♀; 7. B. sylvarum *L.* ♀ and ☿; 8. B. terrester *L.* ♀ (perforating the corollas); 9. Eucera difficilis (Duf.) *Pér.* ♀.

Loew also saw Eucera in Brandenburg; Bombus agrorum *F.* ☿, skg., in the Berlin Botanic Garden; and Megachile sp. in Silesia.

The following bees, &c., were noticed by the observers and at the places stated.—

Schenck (Nassau), 1. Bombus confusus *Schenck*; 2. B. lapidarius *L.*; 3. B. pomorum *Pz.*; 4. Eucera longicornis *L.*; 5. Podalirius retusus *L.*; and 6. the Sphegid Gorytes mystaceus *L.*: Rössler (Wiesbaden), the moth Toxocampa craccae *F.*: Friese (Baden), Andrena xanthura *K.*, n. sp.: Hoffer (Steiermark), 1. Bombus lapidarius *L.* ♀ and ☿; 2. B. derhamellus *K.* ♀ and ☿: Dalla Torre and Schletterer (Tyrol), 1. Bombus derhamellus *K.* ☿; 2. B. variabilis *Schmiedekn.*, var. tristis *Seidl.* ☿; 3. Andrena xanthura *K.* ♀; 4. Halictus major *Nyl.* ♂.

Herm. Müller, in the Alps, saw Bombus mastrucatus *Gerst.* ☿ getting the nectar by perforation ('Alpenblumen,' p. 249). Schulz also noticed humble-bees stealing in the same way.

MacLeod saw Bombus variabilis *Schmiedekn.* ♀ in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 438); and, in Flanders, 2 humble-bees, an Andrena, a Lepidopterid, Bombus terrester *L.* stealing nectar by perforation, Apis and Osmia sucking nectar through the holes thus made (op. cit., vi, 1894, p. 358). H. de Vries noticed a humble-bee, Bombus sylvarum *L.* ♀, skg., in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

In Dumfriesshire 3 humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 50).

Von Fricken, at Arnsberg, saw the Curculionid Brûchus pisi *L.* as an injurious visitor.

764. **V. sativa** L. (Sprengel, 'Entd. Geh.,' p. 357; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892, pp. 96–100; Kirchner, 'Neue Beob.,' p. 44, 'Flora v. Stuttgart,' p. 506; Schulz, 'Beiträge,' II, p. 211; Knuth, 'Bloemenbiol. Bijdragen.')—In this species the alae are usually violet in colour, the vexillum lilac, and the carina whitish with a blue tip. Kirchner says that the union of the alae with the carina, effected in the usual way, is rendered so firm by the mutual interlocking of the epidermal cells of these petals, that the alae tear when pulled apart. The posterior angles of the carina are drawn out into processes which lie upon the sexual column. There are also finger-shaped alar processes, running backwards parallel to each other. The upper filament is united with the other nine, but two nectar-passages are left at its base. The style is about 2 mm. long, and bears a brush on its upper half, the hairs of which are disposed all round it, and directed obliquely upwards. Externally there is a tuft of longer protective hairs, projecting beyond the stigma.

Even in the bud the anthers dehisce, so that automatic self-pollination is inevitable; it is thoroughly effective.

Visitors.—I saw 3 long-tongued bees in Schleswig-Holstein.—1. Bombus agrorum *F.* ♀; 2. B. lapidarius *L.* ♀ and ☿; 3. Eucera longicornis *L.* ♀ and ♂, all skg. legitimately. Sprengel records Sphinx (Deilephila) euphorbiae *L.*

Loew noticed Bombus sylvarum *L.* ♀, skg., in Silesia ('Beiträge,' p. 34). Heinsius observed B. hortorum *L.* as an invited guest, and the brimstone butterfly (Rhodocera rhamni *L.*) as an unbidden one; also Bombus terrester *L.*, stealing nectar by perforation. Schulz, in Central Germany, also noticed flowers perforated by humble-bees.

MacLeod saw Bombus and Eucera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 361).

In Dumfriesshire humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 50).

Heinsius noticed the extra-floral nectaries to be visited by Vespa sylvestris *Scop.*, V. rufa *L.*, Apis, and a fly (Cleigastra sp.).

765. **V. angustifolia** All. (H. von Mohl, Bot. Ztg., Leipzig, xxi, 1863, p. 312; Treviranus, op. cit., xxi, 1863, p. 143; Kuhn, op. cit., xxv, 1867, p. 67; Herm. Müller, 'Weit. Beob.,' II, p. 262; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 64, 153.)—This is regarded as the ancestral form of V. sativa. As early as 1863 Treviranus and Hugo von Mohl called attention to the underground flowers and fruits of V. angustifolia (var. amphicarpos); about 10% of the plants (at Berlin) possess subterranean cleistogamous flowers produced on runners bearing scale-leaves. The mechanism of the ordinary chasmogamous flowers agrees with that of V. sativa.

Visitors.—I saw Bombus cognatus *Steph.*, skg., and B. agrorum *F.*, do., in the North Frisian Islands. Schulz, in Central Germany, noticed flowers perforated by humble-bees.

Herm. Müller observed the following.—

A. Hymenoptera. (*a*) *Apidae*: 1. Bombus agrorum *F.* ☿, skg. persistently; 2. B. muscorum *F.* ☿, skg.; 3. B. sylvarum *L.* ♀, do.; 4. Saropoda rotundata *Pz.*, do. **B. Lepidoptera.** (*a*) *Rhopalocera*: 5. Lycaena aegon *W. V.*, skg. (*b*) *Sphingidae*: 6. Ino pruni *Schiff.*, skg.

Alfken saw a bee, Osmia solskyi *Mor.* ♀, at Bremen.

766. **V. narbonensis** L.—Treviranus (loc. cit.) says that this species produces subterranean fruits.

767. **V. pyrenaica** Pourr.—There are subterranean fruits in this species (Treviranus, loc. cit.).

Visitors.—MacLeod observed 4 species of humble-bee, an Anthophora, an Eucera, and a Bombylius in the Pyrenees.

768. **V. pannonica** Jacq.—Kirchner ('Beiträge,' p. 46) says that the mechanism of the yellowish-white flowers of this species is much the same as that of V. sativa. The vexillum is bright rose-red in colour, with brownish streaks as nectar-guides. The carina is greenish-yellow with a brownish tip. The claw of this petal is so broad that it surrounds all the other internal parts of the flower, and its lower margins curve under the staminal tube, touching each other somewhere about the

middle. The alar laminae possess longitudinal folds, and arch inwards so as to touch each other at the middle of the curvature, in front of the tip of the carina. Near the posterior end of the upper margin of each ala there is a long conical process, which fits into a corresponding depression in the upper margin of the carina. Still further back there are two deep alar folds, and also a shallower one, the inner surfaces of all which are so intimately united with the carina that the alae cannot be separated without tearing them. The rounded posterior lobes of the alar and carinal laminae are directed backwards, and lie above the staminal tube. Their elasticity causes this tube to return into the carina. The upper filament, as in V. sativa, is fused with the others, permitting access to the nectar only by means of passages at its base. There is abundant secretion at the usual place. The claws of the petals are in contact with one another, and 13 mm. long. They are enclosed by the calyx-tube for a distance of 6–7 mm. The stipules serve as extra-floral nectaries, but only a few of them are functional.

VISITORS.—Kirchner, in Wurtemberg, saw a humble-bee (Bombus lapidarius *L.* ☿) on cultivated plants.

769. V. Faba L. (Sprengel, 'Entd. Geh.,' pp. 357–60; Herm. Müller, 'Fertilisation,' pp. 206–7; Darwin, Ann. Mag. Nat. Hist., London, Ser. 3, ii, 1858, p. 460; Mattei, Justs bot. Jahresber., xvii, (1889) 1891, p. 480; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen.')—The fragrant flowers of this species are white with a black spot on each ala. Their mechanism agrees, according to Hermann Müller, with that of V. sepium, but they are much larger. The nectar, however, is more easily accessible, for the vexillum and alae are less firmly held together, and the carina is more readily depressed. The swollen processes on the under-side of the vexillum are also wanting, so that the claw of this petal (13–16 mm. long) is but loosely held by the calyx-tube. On the other hand, the two involutions connecting the alae and carina are present, but the union is less firm than in V. sepium, and the backwardly directed alar processes are much more feebly developed. The alae and carina are but slightly elastic, so that if forcibly depressed they do not return to their original position.

Darwin found that when insects were excluded the plant was only one-third as fertile as when they were allowed to visit the flowers. If, however, the flowers protected from such visits were shaken, healthy seeds were abundantly produced. Mattei describes an Indian variety as adynamandrous.

Only long-tongued bees are able to suck the nectar legitimately, and in doing this to effect cross-pollination. Short-tongued bees either collect pollen on visited flowers with exposed anthers (simultaneously bringing about crossing) or steal nectar by perforation. Bombus terrester *L.* ♀ (proboscis 7–9 mm. long) is notorious in this respect, and very seldom tries to suck legitimately. The honey-bee either steals nectar through the holes made by B. terrester, or collects pollen.

VISITORS.—I observed the following bees in the Island of Rügen.—

1. Apis mellifica *L.* ☿, stealing nectar as above mentioned; 2. Bombus terrester *L.*, perforating the flowers; 3. B. hortorum *L.* ♀, very freq., skg.; 4. B. rajellus *K.* ♀, skg.

Hermann Müller records the following.—

A. Hymenoptera. *Apidae*: 1. Andrena convexiuscula *K.* ♀, po-cltg.; 2. A. labialis *K.* ♂, vainly trying to suck; 3. Apis mellifica *L.* ☿, stealing nectar as above, and po-cltg.; 4. Bombus confusus *Schenck* ♀, freq., skg.; 5. B. hortorum *L.* ♀, do.; 6. B. lapidarius *L.* ♀, do.; 7. B. muscorum *F.* ♀, do.; 8. B. sylvarum *L.* ♀, do.; 9. B. terrester *L.* ♀, perforating; 10. Osmia rufa *L.* ♀, skg. **B. Coleoptera.** *Malacodermata*: 11. Malachius bipustulatus *L.*, po-dvg.

The following were observed by the authorities and at the places stated.—

Alfken (Bremen), the bees, 1. Bombus ruderatus *F.* ♀; 2. B. terrester *L.* ♀, skg. illegitimately: Verhoeff (Norderney and Baltrum), the bees 1. Bombus lapidarius *L.* ♀, skg.; 2. B. cognatus *Steph.* (=B. muscorum *F.*), a ♀, do.: Alfken (A.) and Leege (L.) (Juist), 1. the Syrphid Syrphus pyrastri *L.*, very freq., and the bees 2. Bombus hortorum *L.* (A., L.); 3. B. muscorum *F.* (L.); 4. B. terrester *L.* (L.); H. de Vries (Netherlands), a bee, 1. Apis mellifica *L.* ☿, very freq., and a humble-bee, 2. Bombus agrorum *F.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

770. **V. hirsuta** S. F. Gray (=Ervum hirsutum *L.*). (Herm. Müller, 'Weit. Beob.,' II, pp. 260–2; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 361; Knuth, '*Bl. u. Insekt. a. d. nordfr. Ins.*,' *pp. 62–3.*)—The small bluish-white flowers of this species, though only 4 mm. long, secrete nectar very abundantly. Hermann Müller describes their mechanism as particularly interesting on account of its great simplicity. There are only 6–12 hairs on the style, instead of a brush. The stamens closely surround and partly project beyond the stigma, that therefore gets covered with pollen when the anthers dehisce, which they do in the bud. The carina is open above throughout its whole length, so that the stigma and anthers protrude when it is depressed. When the pressure is removed, the depressed parts return to their original position. This is brought about by the elasticity of the alae and carina, aided by the broad vexillum that ensheaths them; also by the action of the calyx, which holds together the bases of all the petals. Each ala is united with the carina only in one place, where there is an ill-marked fold and the epidermal cells slightly interlock.

Automatic self-pollination regularly takes place, and Hermann Müller says that it is thoroughly effective. Insect visitors effect cross- and self-pollination with equal ease, and, despite the small size of the flowers, their number is considerable. This is obviously due to the relatively great abundance of nectar. While in other species the secretion remains concealed between the base of the pistil and the filaments, it here flows out through the nectar-passage on either side the base of the free filament, collecting to form a large drop. This extends beneath the vexillum beyond the level of the calyx, and hence can be seen from the outside.

Visitors.—These are small bees and Lepidoptera. I saw the honey-bee in the island of Föhr, and Herm. Müller noticed it in Westphalia. Herm. Müller (H. M.) and Buddeberg (Budd.) also observed the following.—

A. Hymenoptera. (*a*) *Apidae*: 1. Andrena convexiuscula *K.* ♂, skg. (H. M.); 2. Halictus flavipes *K.* ♀, do. (Budd.). (*b*) *Sphegidae*: 3. Ammophila sabulosa *L.* ♂, making casual attempts at skg. (H. M.). **B. Lepidoptera.** *Rhopalocera*: 4. Coenonympha pamphilus *L.*, skg. (H. M.); 5. Lycaena aegon *W. V.*, do. (H. M.).

H. de Vries saw a bee, Apis mellifica *L.* ☿, in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

In Dumfriesshire a Muscid and several Dolichopodids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 48).

771. **V. tetrasperma** Moench (= Ervum tetraspermum *L.*).—The mechanism of the bright yellow flowers of this species is not, according to Kirchner ('Flora v. Stuttgart,' p. 504), so much simplified as in the last species, but essentially agrees with that of V. Cracca. The alae possess the finger-shaped processes overlapping the sexual column, and in front of these there are two outgrowths on either side which fit into and are loosely united with corresponding carinal depressions. The upper margins of the carina lie close together; the base of the vexillum ensheaths the claws of the other petals. The anthers dehisce just before the bud opens, and some of the pollen falls upon the collecting-brush.

VISITORS.—I observed the honey-bee and Halictus sp., skg., at Kiel ('Bloemenbiol. Bijdragen').

772. **V. pisiformis** L. (= Ervum pisiforme *Peterm.*).—The greenish to yellowish-white flowers of this species were investigated by Herm. Müller in Thuringia ('Weit. Beob.,' II, pp. 258–60). Their mechanism is intermediate between those of V. sepium and V. Cracca. The style is provided with a very regular brush for almost half its length from the stigma, and the anthers (which dehisce in the bud) deposit the greater part of their pollen upon it. The upper margins of the carina are readily separated, so that when it is depressed the stigma, stylar brush, and all the stamens protrude. Union between carina and alae is effected very much as in V. Cracca and V. sepium. But the finger-shaped processes on the bases of the alar laminae are broader and thicker, triangular in form, and only gradually becoming slender and flattened towards their tips. They consequently cause the return of all the parts of the flower to their original position more efficiently than in the other two species. The vexillum is pressed against the alae by means of two slight folds situated at the junction of its claw and erect lamina, and diverging to the front superiorly. Unbidden guests are thus excluded. Since the claw of the vexillum is 8–10 mm. long, the proboscis of insect visitors must be of the same length. Many shorter-tongued bees, however, are able to thrust their heads under the claw, thus reaching the nectar.

VISITORS.—Herm. Müller observed the following.—

A. Hymenoptera. *Apidae*: 1. Bombus lapidarius *L.* ☿, skg.; 2. B. rajellus *K.* ♀ and ☿, do.; 3. B. sylvarum *L.* ♀, skg. and po-cltg.; 4. Halictus tetragonius *Klg.* ♀, po-cltg.; 5. Megachile circumcincta *K.* ♀, skg. and po-cltg.; 6. M. versicolor *Sm.* ♀, do. **B. Diptera.** *Syrphidae*: 7. Syrphus balteatus *Deg.*, hovering and vainly skg. **C. Lepidoptera.** *Rhopalocera*: 8. Coenonympha arcania *L.*, skg.

A. Schulz saw flowers perforated by humble-bees.

773. **V. sylvatica** L. (= Ervum sylvaticum *Peterm.*).—

VISITORS.—In Dumfriesshire 2 humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 49). Schulz saw flowers perforated by humble-bees.

774. **V. cassubica** L. (= Ervum cassubicum *Peterm.*).—

VISITORS.—Schulz saw flowers perforated by humble-bees.

775. **V. Orobus** DC. (=Ervum Orobus *Kitt.*).—

VISITORS.—MacLeod, in the Pyrenees, saw Bombus mastrucatus *Gerst.* ☿, stealing the nectar by perforation (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 439).

In Dumfriesshire a humble-bee, probably Bombus agrorum *F.*, was observed, but did not appear to suck (Scott-Elliot, 'Flora of Dumfriesshire,' p. 50).

776. **V. Ervilia** Willd. (=Ervum Ervilia *L.*, and Ervilia sativa *Link*).—The odourless white flowers of this species are marked with dark violet veins on the vexillum, and a dark blotch on either side of the carina. Kirchner ('Flora v. Stuttgart,' p. 507) describes the vexillum, which grasps the claws of the other petals from above, as possessing two processes at the base of its lamina. These are closely apposed to the parts of the flower beneath them. Each ala bears a finger-shaped process, in front of which there is a deep fold interlocking with the carina. The brush on the style is about half its length, and composed of uniform fine hairs.

777. **V. onobrychioides** L.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Andrena dorsata *K.* ♀, po-cltg.; 2. Bombus agrorum *F.* ☿, steadily skg.; 3. Megachile willughbiella *K.* ♂, skg.; 4. Osmia aenea *L.* ♀, po-cltg.

778. **V. unijuga** A. Br.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

1. Bombus hortorum *L.* ☿, skg.; 2. B. lapidarius *L.* ☿, do.; 3. B. pratorum *K.* ☿, do.; 4. Megachile circumcincta *K.* ♀, skg. and po-cltg.; 5. M. willughbiella *L.* ♂, skg.; 6. Osmia rufa *L.* ♀, po-cltg.

228. Lens L.

Nectar-yielding bee flowers with a stylar brush.

779. **L. esculenta** Moench (=Ervum Lens *L.*).—The bluish-white flowers of this species are marked with blue lines on the vexillum (nectar-guides), and a small blue patch on the tip of the carina (pollen-guide). Kirchner ('Flora v. Stuttgart,' p. 508) states that the vexillum, which but slightly ensheaths the other parts of the flower, comes into close contact with the alae by means of two forwardly-directed folds of a projecting ridge. The style bears collecting hairs only on its inner side. Otherwise the mechanism agrees with that of Vicia Ervilia. Kerner says that the flowers are fertile when insect-visits are prevented.

VISITORS.—Herm. Müller saw the honey-bee, skg., and a butterfly (Coenonympha pamphilus *L.*), do. ('Weit. Beob.,' II, p. 258).

229. Pisum L.

Nectar-containing bee flowers with a brush arrangement transitional to a pumping one.

780. **P. sativum** L.—The mechanism of the white flowers of this species has been very fully described by Herm. Müller ('Fertilisation,' pp. 211–14). The strong sickle-shaped carina is produced into a leaf-like outgrowth along the junction of its two petals, and is thus strengthened. The alae and carina are very firmly united with one another, and with the sexual column. At the base of each alar lamina

there is a deep involution directed forwards and downwards, and fitting into a corresponding pit in the upper surface of the adjacent carinal petal. The epidermal cells are here so closely interlocked that it is scarcely possible to separate the carina and alae without tearing them. There is also an anterior alar fold, which lies in a carinal depression. The upper side of the base of the vexillum possesses two deep but narrow indentations which project ventrally as firm ridges. These diverge in front and fit into the anterior alar folds. The base of each carinal petal expands into an upwardly and inwardly directed lobe, which rests on the sexual column.

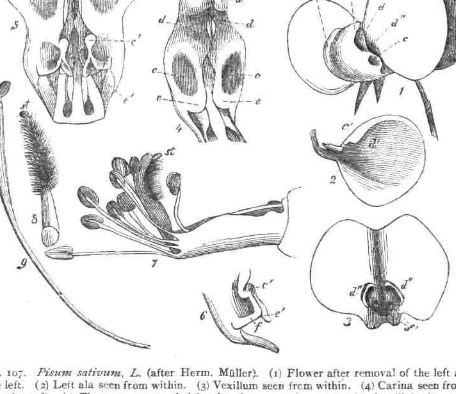


FIG. 107. *Pisum sativum*, *L.* (after Herm. Müller). (1) Flower after removal of the left ala, seen from the left. (2) Left ala seen from within. (3) Vexillum seen from within. (4) Carina seen from above (further enlarged). (5) The same surrounded by the alae; *anterior part omitted* (*still further enlarged*). (6) Basal part of the left ala, seen from the outside. (7) The sexual organs removed from the bud. (8) Upper part of the style, seen from within (× 7). (9) A stamen. *a*, apical carinal swelling; *b*, median carinal outgrowth; *c'*, alar involution, fitting into carinal pit (*c*); *d'*, anterior alar fold, resting in carinal depression (*d*), and overlaid by vexillary ridge (*d''*); *e*, basal carinal lobe; *e'* posterior alar process; *f*, alar plate, held in place by rounded vexillar swelling (*f'*); *l*, tip of carina; *st*, stigma; *o*, stylar opening.

It is kept in place by a posterior alar process, directed backwards and inwards. These processes, in their turn, are grasped by narrow alar plates which project horizontally from them, and are backwardly directed. A rounded swelling on the very broad and firm vexillar base presses against each of these plates.

The style runs up vertically from the end of the horizontal ovary; its end is curved inwards to such an extent that the terminal stigma faces almost directly downwards towards the base of the flower. The inner side of the style is beset with long bristly hairs for almost half its length. The tip of the carina is also directed towards the base of the flower, and dilates into a pair of swellings which enclose the anthers in the bud. The conical space thus bounded possesses an opening through which the style can protrude.

Towards the end of the bud period, the anthers dehisce, filling the conical space at the end of the carina with pollen; at the same time the filaments are retracted. The stigma and stylar brush get covered with pollen, some of which is squeezed out at the tip of the carina when this is depressed. When the parts of the flower resume their original position the edges of the stylar aperture scrape off the pollen, which then of course remains outside the carina. The ends of the filaments lying in the lower part of the conical anther-chamber are somewhat thickened and club-shaped after the anthers have dehisced. When the carina is depressed they push the pollen before them, so that the supply on the stylar brush is constantly renewed.

The interlocking and union of the parts of the flower are advantageous, because nectar-seeking insects are compelled to apply the necessary force in order to operate the mechanism by which the stigma is rubbed against the pollen-covered ventral surface of a visitor, and this is dusted afresh. The firm union of parts also secures return to their original position when the pressure is removed. Besides which, access to the nectar is only permitted to a select number of powerful insects. Bees possessing the requisite strength, however, are scarce, and visitors of this species are consequently few in number. Although the majority of flowers remain unvisited, they are just as fertile when self-pollinated as when crossed (Ogle, Müller, Kerner).

VISITORS.—In the course of four summers, Herm. Müller only observed 3 bees:—1. Eucera longicornis *L.*; 2. Halictus sexnotatus *K.* ♀, skg. and po-cltg., ♂, skg.; 3. Megachile pyrina *Lep.*, do.

A. Schulz noticed flowers perforated by humble-bees.

Alfken saw 2 bees, skg., at Bremen.—1. Anthidium manicatum *F.* ♀; 2. Megachile maritima *K.* ♂.

230. Lathyrus L.

Nectar-containing bee flowers with a stylar brush.

781. **L. pratensis** L. (Delpino, 'Ult. oss.,' pp. 55–9; Herm. Müller, 'Fertilisation,' pp. 207–10, 'Weit. Beob.,' II, p. 257, 'Alpenblumen,' p. 249; Schulz, 'Beiträge,' II, p. 211; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 362–4; Loew, 'Blütenbiol. Floristik,' p. 395; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 201, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 233.)—The mechanism of the yellow flowers of this species, which was first described by Delpino, and afterwards more fully by Hermann Müller, is similar to that of Pisum. The union of alae and carina with the sexual column is effected by two long vesicular alar processes. These run backwards, and rest upon the column, their tips meeting in the middle line. Their elasticity brings about the return of the carina to its original position, on removal of the pressure exerted by an insect visitor. On either side the end of the carina there is a sacculation, bounded behind by a deep fold, and opening only at the carinal tip. These two sacculations jointly enclose all the anthers in the bud; dehiscence takes place at the beginning of anthesis. The style is almost vertical, and expands beneath the oval terminal stigma into an elongated oval plate. The inner side of this is beset with short hairs directed obliquely upwards, which sweep

the pollen clinging to them through the tip of the carina on to the ventral surfaces of bees. This pollen dusts the projecting stigma of the next flower visited, so that crossing is effected. Although the stigma is surrounded by the pollen of the same flower, automatic self-pollination apparently does not take place, the stigmatic papillae needing to be rubbed (by visiting bees) before they become receptive.

VISITORS.—I saw the following bees in the North Frisian Islands.—1. Apis mellifica *L.* ☿. skg.; 2. Bombus derhamellus *K.*, do.; 3. B. terrester *L.*, do.; and also B. agrorum *F.* ♀, do. (Rügen).

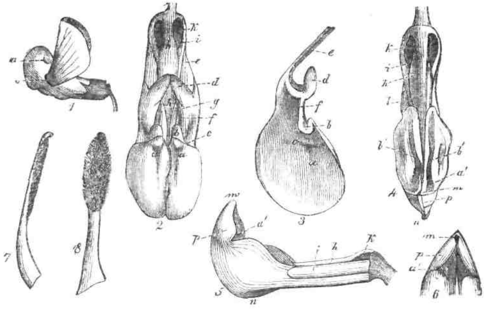


FIG. 108. *Lathyrus pratensis, L.* (after Herm. Müller). (1) Flower seen from the side (slightly enlarged). (2) Flower after removal of calyx and vexillum, seen from above (further enlarged). (3) Left ala, seen from within. (4) Flower after removal of vexillum and alae, seen from above. (5) Bud shortly before opening, after removal of calyx, vexillum, and alae; seen from the side. (6) The anterior part of the same, seen from above. (7) Style with brush and stigma, seen from the side. (8) The same, seen from within. *a*, alar sac, lying in a deeper pouch (*a'*) of the carina; *b*, process of alar margin, directed forward and downward: it interlocks with the narrowest part of the pocket-like carinal sac; *c*, transverse depression in the ala, immediately behind the anterior dark yellow lobe, an angular ridge-like vexillar fold (*o*) is closely connected with it; *d*, posterior process of the upper alar margin; *e*, alar claw; *f*, margin of the ala folded over; *gg*, margins of the carina; *h*, uppermost filament; *i*, fused filaments; *k*, nectar passages, with basal nectaries; *l*, carinal claws; *m*, place at which the tip of the style and the stigma project, when the carina is depressed; *n*, leaf-like expansion along the line of fusion of the carinal petals; *o*, ridge-like processes of vexillum; *p*, terminal sacculation of the carina.

Alfken observed the following bees at Bremen.—

1. Bombus arenicola *Ths.* ☿; 2. B. derhamellus *K.* ♀ and ☿; 3. B. distinguendus *Mor.* ♀ and ☿; 4. B. lapidarius *L.* ☿; 5. B. lucorum *L.* ☿; 6. B. muscorum *F.* ♀; 7. B. sylvarum *L.* ♀; 8. Eucera difficilis (Duf.) *Pér.* ♀ and ♂; 9. Megachile circumcincta *K.* ♂; 10. M. willughbiella *K.* ♀.

Loew noticed Diphysis serratulae *Pz.* ♀, po-cltg., in Steiermark ('Beiträge,' p. 53).

Herm. Müller (H. M.) and Buddeberg (Budd.) noticed the following.—

1 Bombus agrorum *F.* ♀, in large numbers, skg. (H. M., Thuringia); 2. Diphysis serratulae *Pz.* ♀ and ♂, skg. (H. M., Budd.); 3. Eucera longicornis *L.* ♀, do. (H. M., Budd.); 4. Megachile maritima *K.* ♂, do. (H. M.); 5. M. versicolor *Sm.*, skg. and po-cltg. (H. M.).

Herm. Müller saw a humble-bee and a Lepidopterid in the Alps, and von Dalla Torre in the Tyrol noticed the bee Xylocopa violacea *L.* ♀. Schletterer records the latter for the Alps, and Polistes gallica *L.* for Pola.

Lindman saw a Lepidopterid in Scandinavia; and MacLeod observed Bombus sylvarum *L.* ♀ and ☿, in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 364).

Apis, 3 humble-bees and a saw-fly have been recorded for Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 51).

Only bees are able to effect pollination. Lepidoptera are no doubt able to suck the nectar by means of their slender proboscis, but cannot liberate the flower mechanism.

Schulz observed flowers perforated by humble-bees.

782. L. maritimus Bigel. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 64–5, 153, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 233.)—I was originally of the opinion that in this species self-fertilization is possible even in the bud. It appears, however, that though the stigma is from the first surrounded with the pollen of the same flower, cross-pollination is ensured by insect-visits. For the said pollen does not adhere to the stigma, which only becomes receptive after an insect has rubbed against it.

The mechanism essentially agrees with that of L. pratensis. The large brightly coloured blossoms are associated in racemes of 5–8 flowers. The erect vexillum is violet in colour with darker veins; it is 2 cm. long, and its upper part about 1½ cm. broad. At the junction of claw and lamina there is a process 3 mm. long, which fits into corresponding alar folds, so that complete union is effected. The violet alae (1 cm. long, with lamina 5 mm. broad) interlock in their turn with carinal depressions. They escape from the vexillum when depressed by insect visitors, diverging so that the stigma first protrudes, and afterwards the pollen-covered stylar brush. The two alar processes interlock so firmly with corresponding depressions in the carina that they are not separated during insect-visits. Hence, when the pressure is removed, the margins of the alae resume their original position, and this movement is furthered by the stiff claws of the carina. The latter is bent almost at right angles; externally it is bright violet in colour, but white elsewhere; its boat-shaped region is 8 mm. long, and its claws of about the same length. The two carinal petals are fused along the whole of their ventral margins; above they gape a little, but are covered by the overlapping alae. The staminal tube is about 1 cm. long, and the free part of the filaments about the same length.

Pollination is effected by long-tongued bees (humble-bees). These hold on to the flower in the way already described, and suck the nectar secreted at the usual place. Lepidoptera play the part of nectar-thieves, and do not operate the flower mechanism. I observed perforated flowers in the Island of Föhr; there was a hole in the alar claw probably made by short-tongued humble-bees.

Visitors.—In Föhr and Sylt, I saw more particularly 5 species of humble-bee and 3 Lepidoptera, the latter being unbidden guests.

Loew observed the following bees in the Berlin Botanic Garden.—1. Bombus agrorum *F.* ♀, skg.; 2. B. hortorum *L.* ☿, do.; 3. B. lapidarius *L.* ☿, do.; 4. B. pratorum *L.* ☿, do.

Schneider saw 2 bees (Bombus nivalis *Dahlb.* ☿ and ♂, and B. alpinus *L.* ♀ ☿ and ♂) in Arctic Norway (Mus. Aarsh. Tromsø, xvi, 1894).

783. **L. sativus** L.—Kirchner gives the following account of the bright blue or white flowers of this species ('Flora v. Stuttgart,' pp. 511–12). The claw of the large vexillum grasps the bases of the alae from above only. It is, however, attached to them very firmly, for its base possesses two pairs of folds placed almost at right angles to one another, and projecting inwards, so as to fit closely into corresponding depressions of the alae. The front edge of the carina is strengthened by a wing-like appendage, and is curved like an **S**, in such a way that its end lies somewhat to the left. The tip of the right carinal petal is arched outwards, while the left one has a deep terminal fold, in front of which the style lies in the carina. As in Pisum, the alae are firmly united with the carina; the right ala, however, where it lies above the carinal tip, possesses a dilated fold contracting from above downwards, through which the end of the style, with its small stigma, projects when the carina is depressed. The style broadens above, and is compressed from before backwards, but it is turned through an angle of 90° in such a way that its morphological inner side, which bears collecting-hairs directed obliquely upwards, is directed to the left, and its hairless outer surface to the right. The anthers dehisce in the bud, and discharge their pollen into the stylar brush, by which it is transferred to insect visitors.

Visitors.—Kirchner observed the honey-bee on cultivated plants in Wurtemberg. When it settled in the middle of the flower, it was dusted with pollen on its right side behind the head; it regularly effected cross-pollination. It frequently stole nectar by thrusting its proboscis into the right side of the flower, occasionally touching the style with its feet.

784. **L. sylvestris** L. (=L. pyrenaicus *Jord.*). (Delpino, 'Ult. oss.,' pp. 57–8; Herm. Müller, 'Fertilisation,' p. 210; Kirchner, 'Flora v. Stuttgart,' p. 512; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 439.)—Delpino describes the flower of this species as asymmetrical, with an oblique stylar brush; but the asymmetry is less pronounced than in L. sativus. Kirchner says that the vexillum (which is of a rose-purple colour, greenish externally) has a longer claw than V. sativus, but is devoid of inwardly directed folds. Here too the greenish carina is twisted, leaving a narrow nectar-passage on the right side, that is regularly used by the honey-bee when stealing nectar, in doing which it only now and then touches the stigma and pollen with its legs.

Visitors.—Besides the honey-bee, Kirchner observed (Wurtemburg) Lepidoptera, as unbidden guests.

MacLeod saw 3 species of humble-bees (skg. legitimately), and a Lepidopterid in the Pyrenees. Delpino ('Ult. oss.,' I) noticed more particularly Xylocopa, Apis, Bombus, Eucera, and Anthophora; and Loew saw Apis, skg., in the Berlin Botanic Garden. Herm. Müller also observed the honey-bee (skg. and po-cltg.), as well as the following Lepidoptera, all skg., but conferring no benefit:—Pieris rapae *L.*, Plusia gamma *L.*, Rhodocera rhamni *L.*, Vanessa io *L.*, V. urticae *L.*

Alfken observed the following bees at Bremen.—

1. Bombus agrorum *F.* ♀; 2. B. derhamellus *K.* ♂; 3. B. hortorum *L.* ♀ and ☿; 4. B. sylvarum *L.* ☿; 5. Megachile centuncularis *L.* ♀, po-cltg.; 6. M. circumcincta *K.* ♀, do.; 7. M. maritima *K.* ♀, do.; 8. Trachusa serratulae *Pz.* ♀, do.

785. L. tuberosus L.—The purple-red, fragrant flowers of this species are markedly asymmetrical, and according to Kirchner ('Flora v. Stuttgart,' p. 511) their mechanism agrees with that of L. sylvestris, even as regards the torsion of the carina and style.

VISITORS.—Herm. Müller observed the following ('Fertilisation,' p. 210, 'Weit. Beob.,' II, p. 257).—

A. Hymenoptera. *Apidae*: 1. Apis mellifica *L.* ☿, skg. and po-cltg. **B. Lepidoptera.** *Rhopalocera*: 2. Hesperia sp., skg.; 3. Lycaena damon *S.V.*, do.; 4. Pieris rapae *L.*, do. **C. Thysanoptera.** 5. Thrips, freq.

Schletterer and von Dalla Torre (Tyrol) saw the bee Halictus sexcinctus *Fbr.* ♀; and Loew (Berlin Botanic Garden) 2 long-tongued bees (Megachile circumcincta *K.* ♀, skg. and po-cltg.; M. fasciata *Sm.* ♂), skg. Schulz, in Central Germany, noticed flowers perforated by humble-bees.

786. L. heterophyllus L.—

VISITORS.—Schulz (Central Germany) saw flowers perforated by humble-bees.

787. L. palustris L.—The flowers of this species are asymmetrical. Their mechanism has been fully described and illustrated by Heinsius (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, pp. 91–4).

VISITORS.—Heinsius, in Holland, observed 2 humble-bees, Bombus agrorum *F.*, skg. legitimately, and B. scrimshiranus *K.* (proboscis only 9–10 mm. long), po-cltg.; also a butterfly Hesperia sylvanus *Esp.* ♂, perhaps an unbidden guest.

Schulz (Central Germany) saw flowers perforated by humble-bees (loc. cit.).

788. L. latifolius L.—

VISITORS.—Schenck (Nassau) saw the leaf-cutting bee Megachile maritima *K.*; von Dalla Torre and Schletterer (Tyrol) the bee Nomada lineola *Pz.*

Loew observed the following bees and butterflies ('Beiträge,' p. 34).—

(*a*) In Silesia.—1. Apis mellifica *L.* ☿, trying to suck; 2. Megachile maritima *K.* ♀, po-cltg.; 3. Xylocopa violacea *L.* ♀, skg.; 4. Rhodocera rhamni *L.*, trying to suck. (*b*) In the Berlin Botanic Garden.—1. Apis mellifica *L.* ☿, skg. through holes made by humble-bees; 2. Bombus terrester *L.* ♀, vainly trying to suck from the outside; another ♀ was biting holes with its mandibles immediately above the calyx; 3. Megachile fasciata *Sm.* ♂ and ♀, skg.; 4. Vanessa cardui *L.*, skg. (*c*) Ditto, on the var. ensifolius.—1. Megachile fasciata *Sm.* ♀, skg. and po-cltg.; 2. Colias rhamni *L.*, skg.; 3. Pieris brassicae *L.*, do. (*d*) Ditto, on the var. intermedius.—1. Bombus sylvarum *L.* ♀, skg. legitimately and po-cltg.; 2. Megachile fasciata *Sm.* ♀, do.; 3. Lycaena bellargus *Rott.*, skg.; 4. Pieris brassicae *L.*, do.

Plateau noticed the following Hymenoptera.—

1. Bombus muscorum *F.*; 2. B. terrester *L.*; 3. Eucera longicornis *L.*; 4. Megachile ericetorum *Lep.*; 5. Odynerus quadratus *Pz.*; 6. Stelis sp.

789. L. luteus Gren. (=Orobus luteus *L.*).—The flowers of this species are at first yellow, but towards the end of anthesis take on a fiery red colour. According to MacLeod's observations in the Cottian Alps, their mechanism is the same as that of L. pratensis.

VISITORS.—MacLeod saw a species of humble-bee.

790. L. montanus Bernh. (=L. macrorrhizus *L.*, and Orobus tuberosus *Wimm.*).—The flowers of this species are at first rose-red, then lilac, and finally of a faded brown colour.

Kirchner ('Flora v. Stuttgart,' p. 513) describes their mechanism as agreeing almost completely with that of L. pratensis, but the end of the style is somewhat broader.

VISITORS.—Alfken observed the following bees at Bremen.—

1. Andrena convexiuscula *K.* ♀ and ♂; 2. A. xanthura *K.* ♀, skg. and po-cltg.; 3. Coelioxys quadridentata *L.* ♀, sk.; 4. Halictus nitidiusculus *K.* ♀; 5. H. punctatissimus *Schenck* ♀; Megachile circumcincta *K.* ♂.

Schmiedeknecht saw the humble-bees Bombus hortorum *L.* ♀, and B. mastrucatus *Gerst.* ♀, in Thuringia. MacLeod noticed 2 humble-bees in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 434, 440). Loew observed 3 bees in the Berlin Botanic Garden.—1. Anthophora pilipes *F.* ♀, skg.; 2. Bombus agrorum *F.* ♀, do.; 3. B. lapidarius *L.* ☿, do. In Dumfriesshire 2 humble-bees were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 52).

Schulz noticed flowers perforated by humble-bees.

791. **L. odoratus** L.—The flowers of this species smell like honey.

VISITORS.—Herm. Müller saw a bee (Anthidium manicatum *L.*), skg., in Strasburg.

792. **L. niger** Bernh. (=Orobus niger *L.*). (Knuth, 'Bloemenbiol. Bijdragen.')—The flowers of this species studied by me in Schleswig-Holstein possess a mechanism agreeing with that of L. pratensis. The vexillum is purple-red in colour, with a darker nectar-guide; it is about 10 mm. broad, and rises to a height of 8 mm. The tips of the alae are of a bluish-violet; the alar and carinal claws are colourless. The processes and depressions of the alar laminae and carina are even better developed than in A. pratensis; but there is hardly any interlocking of the epidermal cells, so that these petals can easily be separated. The distance from the entrance of the flower to the nectar is 7 mm. The petals become discoloured after anthesis.

VISITORS.—I saw Bombus agrorum *F.*, skg. Loew observed 3 bees in the Berlin Botanic Garden.—1. Bombus agrorum *F.* ♀, skg.; 2. B. lapidarius *L.* ☿, do.; 3. Osmia rufa *L.* ♀, skg. and po-cltg.

MacLeod noticed Bombus agrorum *F.* ♀ in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 439). Bombus terrester *L.* also visits the flowers. It bites through the base of the vexillum from above, or at the tip, and steals nectar through the opening, which is sometimes 4 mm. long and 2 mm. broad.

Schulz (Central Germany) also saw flowers perforated by humble-bees.

793. **L. variegatus** Ten.—

VISITORS.—Loew noticed 2 long-tongued bees in the Berlin Botanic Garden.—1. Bombus hortorum *L.* ☿, skg.; 2. Osmia rufa *L.* ♀, skg. and po-cltg.

Schenck saw 2 bees in Nassau.—1. Megachile ericetorum *Lep.*; 2. Xylocopa violacea *L.*

Schulz (Central Germany) noticed flowers perforated by humble-bees.

794. **L. setifolius** L.—Kiefer states that this species bears cleistogamous flowers.

795. L. vernus Bernh. (=Orobus vernus *L.*). (Knuth, 'Bloemenbiol. Bijdragen.')—The flower mechanism of this species is almost exactly like that of L. pratensis. The vexillar lamina is 12 mm. broad and 6 mm. long, and dark purple-red in colour, with delicate darker markings. The vexillar claw is 10 mm. long, white at the base, and almost enclosed by the calyx, like the remaining parts of the flower. The exposed portions of the vexillum and carina are violet in colour, while the parts enclosed by the vexillar claw and calyx are white. The union between carina and alae is tolerably firm, but with care they can be separated from one another without tearing. The style gradually tapers upwards; its brush is 3 mm. long.

The anterior parts of the petals become blue towards the end of anthesis.

VISITORS. — Schmiedeknecht mentions Bombus mastrucatus *Gerst.* ♀ for Thuringia, and Hoffer records it for Steiermark.

I observed 3 humble-bees at Kiel (2. 5. '96).—1. Bombus hortorum *L.* ♀, freq., skg. legitimately, and diligently flying from flower to flower; 2. B. lapidarius *L.* ♀, occasionally do.; 3. B. terrester *L.* ♀, perforating the vexillar claw just between the two upper calyx-teeth, and thus stealing nectar. Schulz also observed flowers perforated by humble-bees.

Loew, in the Berlin Botanic Garden, observed Bombus hortorum *L.* ♀, skg., and B. terrester *L.* ♀, perforating the flowers; also, on the var. flaccidus *Kit.*, Osmia rufa *L.* ♀, skg. and po-cltg.

796. L. Aphaca L.—The bright or dark yellow odourless flowers of this species possess nectar-guides in the form of dark streaks on the vexillum. Kirchner ('Flora v. Stuttgart,' p. 514) states that their mechanism agrees with that of L. pratensis, except that the style enlarges but slightly and gradually towards its end.

797. L. Nissolia L.—Kirchner ('Flora v. Stuttgart,' p. 515) says that the rather small carmine-red flowers of this species frequently do not open at all, but nevertheless set healthy fruits, being therefore cleistogamously fertilized.

798. L. grandiflorus Sibth. et Sm.—This species is very rarely visited by insects in England. The flowers are more fertile when shaken (Darwin, Ann. Mag. Nat. Hist., London, Ser. 3, ii, 1858, p. 459).

VISITORS.—Loew observed a bee (Megachile fasciata *Sm.* ♀), po-cltg. and skg., in the Berlin Botanic Garden.

799. L. brachypterus Alef.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Bombus agrorum *F.* ☿, skg.; 2. B. lapidarius *L.* ☿, skg. and po-cltg.; 3. B. terrester *L.* ♂, trying to perforate just above the calyx; 4. Megachile centuncularis *L.* ♀, skg. and po-cltg.; 5. M. fasciata *Sm.* ♂ and ♀, *in copulâ* on the flowers, the ♀ previously skg. and po-cltg.

800. L. cirrhosus Ser.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Bombus agrorum *F.* ☿, skg.; 2. B. hortorum *L.* ☿, skg. and po-cltg.; 3. B. lapidarius *L.* ☿, do.; 4. Eucera longicornis *L.* ♀, do.

801. **L. incurvus** Roth.—

VISITORS.—Loew (Berlin) saw a humble-bee (Bombus agrorum *F.* ☿) pressing the alae together normally, skg. and po-cltg.

802. **L. rotundifolius** Willd.—

VISITORS.—Loew (Berlin) observed 2 bees:—1. Bombus agrorum *F.* ♀, inserting its proboscis laterally under the vexillum; 2. Megachile fasciata *Sm.* ♂. skg.

231. Orobus L.

803. **O. aureus** Stev.—

VISITORS.—Loew (Berlin) saw 2 humble-bees.—1. Bombus agrorum *F.* ♀, skg.; 2. B. lapidarius *L.* ♀, do.

804. **O. hirsutus** L.—

VISITORS.—Loew (Berlin) saw 2 bees.—1. Bombus agrorum *F.* ♀, skg.; 2. Megachile fasciata *Sm.* ♂, do.

805. **O. Jordani** Tenore.—

VISITORS.—Loew (Berlin) saw a humble-bee (Bombus hortorum *L.* ☿), skg. and po-cltg.

232. Erythrina L.

806. **E. Crista-galli** L. (Delpino, 'Ult. oss.,' pp. 64–8; Herm. Müller, 'Weit. Beob.,' II, p. 264.)—The flower of this Brazilian species is twisted through an angle of 180°, so that the large vexillum is directed downwards, and serves as an alighting-place and platform for visitors. The stamens and style are enclosed by the upwardly directed carina, the lower part of which is expanded into a nectar-reservoir. The alae are only represented by two vestigial laminae. Cross-pollination is favoured by the fact that the stigma projects a little beyond the anthers.

VISITORS.—Delpino supposes that humming-birds are the pollinating agents.

807. **E. velutina.** (Delpino, op. cit.)—In this species the alae and carina are reduced to minute vestiges, so that the column of sexual organs lies free under the vexillum.

VISITORS.—Delpino believes these to be bees that must thrust in their heads between the sexual column and the vexillum to reach the nectar, which is secreted as in papilionaceous flowers generally.

233. Glycine L.

808. **G. chinensis** Sims. (= Wistaria chinensis *DC.*).—The large blue flowers of this species are associated in many-blossomed racemes.

VISITORS.—Herm. Müller observed the following bees at Strasburg ('Weit. Beob.' II, p. 263).—

1. Anthidium manicatum *L.* ♂, skg.; 2. Anthophora personata *Ill.* ♀ and ♂, do.; 3. Megachile willughbiella *K.* ♂, do.; 4. Osmia aenea *L.* ♀, do.; 5. O. rufa *L.* ♀, do.

Loew saw the honey-bee, skg., in the Berlin Botanic Garden.

Schletterer records the widely distributed carpenter-bee Xylocopa violacea *L.* for the Tyrol.

234. Phaseolus L.

Nectar-yielding bee-flowers with a stylar brush. The spirally twisted end of the style, with the stigma and the pollen adhering to the brush, projects from the tip of the carina (which is also spirally twisted) when this is depressed, returning again when the pressure is removed. Delpino ('Ult. oss.,' p. 55) says that in some species the style is twisted to the right, in others to the left, and that all intermediate stages exist between a simple falciform curve (P. angulosus, &c.) and a helicoid spiral of 4 to 5 turns (P. Caracalla).

809. P. vulgaris L. (Herm. Müller, 'Fertilization,' pp. 216–17; Kirchner, 'Flora v. Stuttgart,' pp. 515–16; Knuth, 'Bloemenbiol. Bijdragen.')—The flower mechanism of this species was first described by Darwin (Gard. Chron., London, 1857, p. 725, 1858, pp. 824–44, Ann. Mag. Nat. Hist., London, Ser. 3, ii, 1858, pp. 459–64). He also demonstrated by experiment that insect-visits are necessary

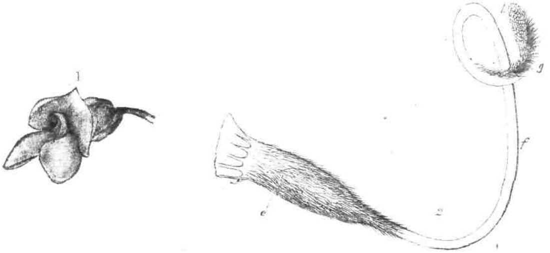


FIG. 109. *Phaseolus vulgaris*, L. (1) Flower seen obliquely from the front (from nature). (2) Pistil enlarged (after Herm. Müller). *e*, ovary; *f*, style; *g*, stylar brush; *h*, stigma.

for fertilization. The bean, however, is able to fertilize itself with complete effect. Darwin's account is here substantially repeated. The left ala is larger than the right. The base of the alar lamina is contracted, and bears an oblique tooth-like process, firm and succulent, which fits into a carinal pit. On the lower third of the ala, internally, there is a crescentic fold, adapted to a corresponding groove in the carina. The latter is small, and the opening at its tip faces downward, lying above the tooth-like process of the right ala. The end of the style is somewhat expanded, and the oblique stigmatic surface is beset with a dense fringe of short hairs. This not only prevents the proboscis of an insect while being withdrawn from coming into contact with the stigma of the same flower, but also prevents the escape of the stigmatic fluid, which is abundantly secreted by the stigmatic papillae when torn by contact with the rough bodies of insects.

The anthers surround the style and shed their pollen upon it, but the stigma is never dusted. The upper free filament broadens out so much immediately in front of the two nectar-passages that it grasps the edges of the staminal tube, completely closing it. There is here an oblique scale-like appendage directed upwards and

forwards. Insects can only obtain nectar legitimately by alighting upon the left ala and pushing their proboscis under the opening on the right side of the carinal tip. To prevent access in any other way, there is here an upwardly and forwardly directed scale-like appendage.

Only large humble-bees are able to work the flower mechanism. When the carina is depressed the end of the style with its pollen-covered brush springs out of the opening in the carina, and a narrow canal appears, beginning just below the carinal opening, and running past the end of the style, along the right margin of the groove in the staminal column as far as the base of the nectary. The upper free stamen retains its position, while the nine united ones are bent downwards. As the stigma is touched by the proboscis of an insect visitor before the pollen, it follows that cross-pollination is regularly effected by visits. Automatic self-pollination is excluded: unvisited flowers remain infertile, as already stated.

VISITORS.—I saw, at Kiel, Bombus hortorum *L.* ♀, skg. legitimately. In spite of constant watching, I have but seldom observed insect-visits, and automatic self-pollination takes place in the large majority of cases, though Darwin was of the contrary opinion (*vide supra*). Some humble-bees obtain the nectar by perforation: I observed Bombus terrester *L.* as a nectar-thief at Kiel.

Alfken saw a bee (Megachile maritima *K.* ♀) at Bremen, and another (Osmia maritima *Friese* ♀) in Juist. Leege observed (Juist) a bee (Osmia maritima *Friese* ♀), freq., skg. and po-cltg., a hawk-moth (Deilephila galii *Rott.*), and a Noctuid (Chariclea umbra *Hfn.*) very freq.

810. **P. multiflorus** Willd. (Herm. Müller, 'Fertilisation,' p. 217; Kirchner, 'Flora v. Stuttgart,' pp. 575–6; Knuth, 'Bloemenbiol. Bijdragen.')—The flower mechanism of this species agrees completely with that of P. vulgaris, and was first described by Farrer (Ann. Mag. Nat. Hist., London, Ser. 4, ii, 1868, pp. 256–60).

According to Ogle (Pop. Sci. Rev., London, ix, 1870, p. 166), the flowers are infertile when bees are excluded, but Kirchner says that they can produce perfect fruits by self-fertilization. The honey-bee and other small bees which are too feeble to depress the carina, use the holes made by Bombus terrester *L.* in the calyx for stealing nectar. Hermann Müller states that more powerful bees, with a sufficiently long proboscis, alight upon the left ala and first touch the stigma with the base of their proboscis, when they thrust it into the base of the flower, and thus effect cross-pollination as in P. vulgaris. As the interlocked alae and carina are pressed downwards, the spirally twisted end of the style protrudes from the tip of the carina, which is also coiled into a spiral of two turns. The stigma faces downwards and to the left, while the pollen-covered stylar brush rubs against the base of the bee's proboscis, and dusts it afresh. When insects visit the flowers cross-pollination is therefore assured, and self-pollination prevented. Hermann Müller states that automatic self-pollination is impossible, as the stigma projects from the tip of the carina, while the pollen is enclosed within it.

VISITORS.—I several times observed (at Kiel) Bombus hortorum *L.* ♀ as an invited guest. Schletterer records Eucera longicornis *L.* for the Tyrol.

235. Apios Moench.

811. **A. tuberosa** Moench.—According to Loew's investigations (Flora, Marburg, lxxiv, 1891) this species bears Lepidopterid flowers in which the carina, pp. 160–71, is fixed, and there is no mechanical union between it and the alae. The protrusion of anthers and stigma from the carina, which is the usual way of dusting the ventral surface of visitors and effecting pollination, is thus rendered impossible. In place of this mechanism the flower has acquired another method of securing cross-pollination, by the remoteness of stigma and anthers from one another, and besides, the nectar passages are shorter and more accessible, so that insects can suck more easily. (Cf. p. 261.)

236. Alhagi Tourn.

812. **A. camelorum** Fisch.—

Visitors.—Morawitz saw the Buprestid Sphenoptera karelini *Falderm.* in the Caucasus.

2. Sub-order Caesalpiniaceae R. Br.

Flowers bilaterally symmetrical (zygomorphous). Scarcely or not at all papilionaceous. Petals 5, sometimes entirely or partly absent; stamens 10, frequently fewer or more (2–15), free or united in various ways; some of them may be sterile.

237. Gleditschia L.

Inconspicuous green flowers which secrete nectar abundantly in the hollow of the calyx. The hermaphrodite flowers are protogynous.

813. **G. triacanthos** L.—Kirchner ('Neue Beob. ü. d. Bestäubungseinricht. einheimisch. Pfl.,' Stuttgart, 1886) says that the fragrant richly nectariferous flowers of this species are monoecious-polygamous, and possibly dioecious. The four green sepals and petals are united below into a cup, which secretes nectar abundantly on its inner surface. It is protected by hairs on the bases of the stamens. The hermaphrodite flowers are protogynous. The hairy elongated ovary bears a large terminal stigmatic cushion, which projects several millimetres from the flower, while the stamens are still enclosed in the perianth. The male flowers usually possess 5–7 projecting stamens, and there is no trace of a pistil. The female flowers bear stamens with vestigial anthers.

Visitors.—Kirchner noticed numerous insects, especially bees.

238. Cercis L.

814. **C. Siliquastrum** L.—

Visitors.—Loew noticed honey-bees, skg., in the Berlin Botanic Garden.

239. Parkinsonia.

815. **P. aculeata** L.—Lanza ('Note di biologia fiorale,' 1894) states that this species is dichogamous in the Palermo Botanic Garden. The vexillum of the fertilized flower changes colour.

Visitors.—Lanza observed Xylocopa cyanescens *Brull.*

240. Cassia L.

816. **C. marylandica** L.—In this species the anthers do not dehisce, but remain covered by a thin membrane, which is ruptured by humble-bees (Nature, London, xxxv, 1886).

XXXIV. ORDER *ROSACEAE* JUSS.

(Including Drupaceae DC. (=Amygdalaceae Juss.) and Pomaceae Lindl.)

Literature.—Hermann Müller, 'Fertilisation,' pp. 221–43; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 65–6, 'Grundriss d. Blütenbiol.,' pp. 51–2.

In this order the flowers are made conspicuous in very different ways in the various genera: there are numerous transitions from the insignificant little blossoms of Alchemilla to the large ones of roses, which are conspicuous from a distance. The inflorescences are equally varied, even in the species of the same genus: sometimes the flowers are solitary or in pairs (species of Mespilus, Cydonia, Dryas, Geum, Rosa, and so forth); sometimes they are aggregated into more or less copiously branched inflorescences—cymes, capitula, racemes, umbels, or panicles (Spiraea, Crataegus, Pyrus, Sorbus, Alchemilla, Sanguisorba, Amygdalus, Prunus, Potentilla, Agrimonia, and so on). Many secrete nectar from an annular ridge on the inner surface of the receptacle. The quantity varies greatly: from large drops (e. g. in species of Rubus and in Geum rivale), to a scarcely perceptible layer, which, however, is eagerly licked by insects (Alchemilla and Potentilla); and there are also intermediate stages. Some species are quite nectarless, others are even anemophilous. Our native forms, therefore, belong to the following flower classes.—

An: Sanguisorba minor.
Po: Rosa, Ulmaria, Aruncus, Kerria.
E: Alchemilla, Sibbaldia, Amelanchier vulgaris.
EC: Amygdalus, Prunus, Geum, Potentilla, Spiraea, Crataegus.
C: Rubus, Comarus, Sorbus, Fragaria, Persica.

It follows from what has been said that the visitors of the various species are very diverse. Flies, especially hover-flies, and short-tongued bees (Andrena, Halictus), are commonest, while the more conspicuous flowers, and those rich in nectar, are also visited by long-tongued bees, as well as beetles and even Lepidoptera. Cross-pollination by insects is frequently favoured or secured by protogyny (Prunus, Amygdalus, species of Spiraea, Geum, Fragaria, Crataegus, Sorbus, and Pyrus), by divergence of the stamens from the stigma in homogamous flowers (species of Persica, Prunus, Rosa, and Potentilla), rarely by protandry (Rubus caesius), or partial dicliny (Sanguisorba minor). Automatic self-pollination appears regularly to take place in hermaphrodite flowers should insect-visits fail.

241. Amygdalus L.

Flowers protogynous, bright rose-red or white in colour, with half-concealed nectar secreted in the lower part of the cup-shaped receptacle.

817. **A. communis** L. (=Prunus Amygdalus *Stokes*).—Kirchner ('Flora v. Stuttgart,' pp. 460–1) says that in this species nectar is secreted by the yellow inner

surface of the lower part of the cup-shaped receptacle. It is protected from rain and unbidden guests by woolly hairs which cover the ovary and the lower part of the style. The numerous stamens are inserted into the receptacle at very different heights, so that some of the anthers are on a level with the stigma, while others project beyond it. When the flower opens, the stigma is already mature; the anthers then gradually dehisce and get covered with pollen on all sides, so that in the event of an insect-visit either cross- or self-pollination may take place. The latter may also be effected automatically.

VISITORS.—I have observed the following on cultivated plants ('Bloemenbiol. Bijdragen').—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*, skg. and po-dvg. **B. Hymenoptera.** (*a*) *Apidae*: 2. Bombus terrester *L.* ♀, skg.; 3. Halictus cylindricus *F.* ♀, do. The humble-bee usually alighted on the petals, and then crept under the stamens to get at the nectar. In doing so it brushed the anthers with its back, but did not touch the stigma. More rarely, it settled on the middle of the flower, i.e. on the stigma, and then crept to the stamens, so that its under-surface was covered with pollen: in this case cross-pollination was effected. (*b*) *Vespidae*: 4. Vespa sp., skg.

Ducke saw the rufous bee Osmia cornuta *Ltr.* ♀ and ♂, freq., at Trieste. Schletterer noticed 2 bees at Pola:—1. Bombus terrester *L.*; 2. Xylocopa violacea *L.*

On the foliage-leaves of this species there are extrafloral nectaries (Kirchner, 'Flora v. Stuttgart,' p. 461), which are visited by ants and wasps, that afford protection against caterpillars and other harmful animals.

818. **A. nana** L. (=Prunus nana *Stokes*).—Kirchner has also described the pollination of cultivated plants of this species ('Neue Beob. ü. d. Bestäubungseinricht. einheimisch. Pfl.,' Stuttgart, 1886, p. 36). The length of the receptacle is 10 mm. and the diameter of its throat is 4 mm.; it narrows somewhat below. The lower part of its inner surface is yellow in colour, and secretes nectar, which is protected from rain and unbidden guests as in the last species, the ovary and that part of the style included in the receptacle being beset with many woolly hairs. The upper glabrous region of the style projects 2–3 mm. from the receptacle. Here also the stamens are inserted at very different heights on the cup-shaped floral receptacle, and the filaments are of various lengths, so that the anthers of the shortest stamens are on a level with the stigma or even lower, while those of the longer stamens project beyond it. When the flower opens the anthers are still closed; the already mature stigma is at first covered by the stamens, which project vertically upwards. Subsequently the anthers successively dehisce in no particular order, and get dusted with pollen all round, so that automatic self-pollination can now readily take place. Whether this is effective or not seems doubtful, as the numerous bushes observed by Kirchner but rarely set fruits.

242. **Persica** Tourn.

Homogamous, bright rose-red flowers with concealed nectar, secreted in the base of the receptacle.

819. **P. vulgaris** Mill. (=Prunus Persica *Stokes* and Amygdalus Persica *L.*). (Herm. Müller, 'Weit. Beob.,' II, p. 244; Kirchner, 'Neue Beob. ü. d. Bestäubungs-

einricht. einheimisch. Pfl.,' Stuttgart, 1886, pp. 36–7; Knuth, 'Bloemenbiol. Bijdragen.')—In this species the cup-shaped receptacle is 8 mm. long; for a height of 5 mm., according to Herm. Müller, it is lined with an orange-coloured layer that secretes nectar. The flowers are therefore better adapted for visits from long-tongued insects than the other flowers of this order. Kirchner states that the roots of the filaments are so curved towards the style as to lie closely together, thus blocking the entrance to the receptacle and its contained nectar. The size of the flowers varies greatly in the different varieties.

VISITORS.—In the Kiel Botanic Garden I noticed the honey-bee, skg., and also 2 humble-bees.—1. Bombus lapidarius *L.* ☿, skg.; and 2. B. terrester *L.* ♀, do. Kirchner saw Apis, Bombus sp., and Vanessa urticae *L.* in Wurtemburg. Herm. Müller observed, besides Meligethes, several bees.—1. Andrena albicans *Müll.* ♀ and ♂, po-cltg. and skg.; 2. Bombus terrester *L.* ♀, skg.; 3. Osmia cornuta *Ltr.* ♀ and ♂, do.; 4. O. rufa *L.* ♂, do. Schletterer saw 2 bees at Pola.—1. Bombus terrester *L.*; 2. Xylocopa violacea *L.* Plateau noticed 3 bees in Belgium.—1. Apis, freq.; 2. Bombus lapidarius *L.*; 3. Osmia bicornis *L.*

243. Prunus L.

White, homogamous or protogynous flowers, with half or completely concealed nectar, secreted in the receptacle.

820. P. Armeniaca L.—The flowers of this species are white, with a reddish tinge; they exhale an odour of honey, and Kirchner says that they are homogamous ('Neue Beob. ü. d. Bestäubungseinricht. einheimisch. Pfl.,' Stuttgart, 1886, p. 37). The red receptacle forms a cup 7–8 mm. deep, and nectar is secreted by the orange-yellow lower part of its wall, so as to be quite concealed. The stamens are either erect or directed somewhat outwards, so that the access to the nectar is not closed. The ovary and lower part of the style are covered with hairs, that serve to protect the nectar.

VISITORS.—Herm. Müller observed only Hymenoptera ('Weit. Beob.,' II, p. 244).—

(*a*) *Apidae*: 1. Andrena fasciata *Wesm.* ♀, po-cltg.; 2. A. parvula *K.* ♀, do.; 3. Halictus leucozonius *Schr.* ♀, skg.; 4. H. sexstrigatus *Schenck* ♀, po-cltg. and skg.; 5. Osmia rufa *L.* ♂, freq., skg. (*b*) *Pteromalidae*; 6. Chalcis sp., skg.

Schletterer saw the carpenter-bee Xylocopa violacea L. at Pola.

821. P. domestica L. (Kirchner, 'Beiträge,' p. 35; Herm. Müller, 'Fertilisation,' p. 222; Knuth, 'Bloemenbiol. Bijdragen.')—The flowers of this species are white with a greenish tinge, and Kirchner says that they are protogynous, though Herm. Müller describes them as homogamous. The first female condition, according to Kirchner, lasts almost two days, after which the anthers dehisce; the flowers remain for three days in the hermaphrodite condition, so that the whole period of anthesis is five days. Cross-pollination is therefore only possible in the first stage. Since the stigma projects beyond the inner stamens, while the outer ones are at the same level, insects are likely to bring about cross-pollination, as they suck the nectar secreted by the fleshy lining of the receptacle, for they usually touch the stigma and anthers of the same flower with different sides of their bodies. In flowers that are

not quite erect, automatic self-pollination can easily take place during the second stage, should insect-visits fail, the pollen falling from the outer longer stamens upon the stigma.

VISITORS.—I saw the following at Kiel.—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.* **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg.; 3. Bombus terrester *L.* ♀, do. **C. Lepidoptera.** *Rhopalocera*: 4. Pieris sp., skg.

Herm. Müller gives the following list for Prunus domestica, P. avium, and P. cerasus ('Fertilisation,' p. 222).—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, skg.; 2. E. tenax *L.*; 3. Rhingia rostrata *L.*, freq., skg. **B. Hymenoptera.** *Apidae*: 4. Andrena albicans *Müll.* ♀ and ♂, very freq., po-cltg. and skg.; 5. A. fulva *Schr.* ♀, skg. and po-cltg.; 6. Apis mellifica *L.* ☿, very common, skg.; 7. Bombus hortorum *L.* ♀, do.; 8. B. lapidarius *L.* ♀, do.; 9. B. terrester *L.* ♀, do.; 10. Osmia cornuta *Ltr.* ♀ and ♂, do.; 11. O. rufa *L.* ♀ and ♂, freq., do. **C. Lepidoptera.** *Rhopalocera*: 12. Pieris brassicae *L.*, skg.; 13. P. napi *L.*, do.; 14. P. rapae *L.*, do.

MacLeod observed Apis in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 325).

822. P. cerasifera Ehrh. (Knuth, 'Bloemenbiol. Bijdragen.')—Focke says that this species is somewhat infertile when isolated.

VISITORS.—I observed Andrena albicans *Müll.* ♀, skg.

823. P. insititia L.—Kirchner ('Beiträge,' p. 35) says that the flower mechanism of this species agrees with that of P. domestica, but cross-pollination is more likely to occur, for the style sometimes exceeds the longest stamen in length.

VISITORS.—In the Kiel Botanic Garden I only observed Andrena albicans *Müll.* ♀, skg.

824. P. avium L.—For this species Kirchner ('Beiträge,' pp. 32–4) gives the following account, supplementing the observations of C. K. Sprengel and Herm. Müller ('Fertilisation,' p. 222). The pure white flowers are faintly fragrant. The corolla does not usually flatten itself out, but forms an almost hemispherical bell, about 10–12 mm. deep, and 17–25 (on an average 22) mm. in diameter. The flower is generally pendulous, and therefore faces downwards. Owing to the shape and arrangement described the stamens and pistil of the sweet cherry are much better protected against rain than is the case in other fruit trees. The length of anthesis is 7–8 days. The flowers are homogamous, but automatic self-pollination cannot normally take place. The stamens are of different lengths: those nearest the centre being only 2–3 mm. long, while the outermost ones are 9–11 mm.

The stigma is mature when the flower opens; it stands at about the same level as the longest stamens. The stamens are divergent and, except in the case of a few of the short (inner) ones, their anthers are still unripe. The pollen of those which have dehisced can scarcely reach the stigma. Dehiscence progresses centrifugally in a not very regular fashion, so that on the second day of anthesis a number of the outer anthers are still closed, but these dehisce extrorsely in the course of the day. The style projects in the middle of the flower beyond the obliquely diverging stamens. These relative positions are maintained till the flower fades, so that automatic self-pollination is infrequent, and can only occur accidentally. Insects

probing the base of a flower to get the nectar secreted on the inner surface of the receptacle generally touch the stigma and pollen with opposite sides of their heads, and therefore effect cross-pollination. Pollen-devouring insects, on the other hand, bring about cross- and self-pollination indifferently.

VISITORS.—I observed the following at Kiel ('Bloemenbiol. Bijdragen ').—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, skg.; 2. Rhingia rostrata *L.*, do. **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg.; 4. Bombus lapidarius *L.* ♀ and ♂, do.

Herm. Müller records the following for Jena ('Weit. Beob.,' II, p. 244).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Tetrops praeusta *L.* (*b*) *Chrysomelidae*: 2. Haltica sp. **B. Hymenoptera.** *Apidae*: 3. Anthophora aestivalis *Pz.* ♂ and ♀, skg. and po-cltg.; 4. Apis mellifica *L.* ☿, do.; 5. Halictus maculatus *Sm.* ♀, po-cltg.; 6. Osmia aurulenta *Pz.* ♂ and ♀, skg.; 7. O. fusca *Chr.* ♀, po-cltg.

Loew noticed the following bees in Brandenburg ('Beiträge,' p. 37).—

1. Andrena combinata *Chr.* ♀, skg.; 2. A. nigroaenea *K.* ♀, do.; 3. A. pilipes *F.* ♀, do.; 4. A. tibialis *K.* ♂, do.; 5. A. varians *K.*, var. helvola *L.* ♀, do.; 6. Nomada alternata *K.* ♂; 7. Osmia rufa *L.* ♂, skg.

MacLeod saw Apis, and Bombus terrester *L.*, in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 323).

825. **P. Cerasus** L.—The results of Kirchner's investigations on this species ('Beiträge,' pp. 34–5) differ in not unimportant particulars from the account given by Sprengel and Müller. The flowers smell like bitter almonds, and are mostly borne upon horizontal stalks, though not infrequently these may be directed obliquely upwards or downwards. The petals spread out to form a flat surface, of which the diameter is 28–31 mm. (on an average 30 mm.). The anthesis of individual flowers lasts 7–8 days. The flowers are protogynous (Herm. Müller described them as homogamous). The stigma is at about the same level as the anthers of the longest stamens.

When the flower opens, the stigma is already mature, but the anthers are all closed, so that at this stage insect visitors must effect cross-pollination. While the flower is fully expanding, the anthers of the inner stamens begin to dehisce in the course of the first day. Dehiscence is centrifugal and extrorse, so that in the great majority of flowers automatic self-pollination cannot take place.

VISITORS.—I observed a small bee, Andrena albicans, *Müll.* ♀, skg., at Kiel ('Bloemenbiol. Bijdragen ').

Schmiedeknecht saw Bombus pratorum *L.* ♀, in Thuringia, and Schenck 2 cuckoo-bees in Nassau.—1. Nomada fabriciana *L.*, var. nigrita *Schenck*; 2. N. rhenana *Mor.*

Alfken and Höppner (H.) observed the following bees at Bremen.—

1. Andrena albicans *Müll.* ♀; 2. A. albicrus *K.* ♀; 3. A. argentata *Sm.* ♀; 4. Bombus agrorum *F.* ♀ (H.); 5. B. derhamellus *K.* ♀ (H.); 6. B. lapidarius *L.* ♀ (H.); 7. B. terrester *L.* ♀ (H.); 8. Nomada alboguttata *H.-Sch.* ♂; 9. Osmia rufa *L.* ♀.

Bees were also noticed as follows.—

Friese (Mecklenburg), Osmia rufa *L.* ♀. Loew (Brandenburg), Andrena propinqua *Schenck* ('Beiträge,' p. 37). Plateau (Belgium), 1. Andrena fulva *Schr.* (=A. vestita *F.*); 2. Apis; 3. Osmia bicornis *L.*

In Dumfriesshire Apis and a parasitic humble-bee have been recorded (Scott-'iot, 'Flora of Dumfriesshire,' p. 53).

826. P. spinosa L. (Herm. Müller, 'Fertilisation,' p. 221, 'Weit. Beob.,' II, p. 244; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 323–4; Knuth, 'Bloemenbiol. Bijdragen.')—In the principal variety of this species the fragrant white flowers appear before the leaves. They so abundantly bedeck the numerous dark branches of the thorny shrub that it can be seen from a distance, so that at the time of anthesis the blackthorn is the most conspicuous member of our flora. The blossoms are consequently visited by numerous insects, which either seek out the nectar secreted abundantly in the base of the receptacle or else collect pollen. They are protogynous: when the flower-buds expand the anthers are still closed, while the style projects a few millimetres beyond the crowded central mass of stamens, and as the stigma is already receptive, cross-pollination must be effected by insects that have previously visited an older flower in the male stage. The stamens subsequently elongate, spread themselves out, and open their anthers. The style also becomes longer, so that it projects somewhat beyond the shorter stamens. The stigma remains receptive, so that, should insect-visits fail, automatic self-pollination can take place.

VISITORS.—Hermann Müller (H. M.) and myself (Kn.) have observed the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes, nect-skg. (H. M., Kn.). **B. Diptera.** (*a*) *Bibionidae*: 2. Bibio marci *L.*, nect-lkg. (H. M.). (*b*) *Empidae*: 3. Empis rustica *Fall.*, skg. (H. M.). (*c*) *Muscidae*: 4. Species of Anthomyia, skg. (H. M.); 5. Chlorops sp., do. (H. M.); 6. Musca domestica *L.*, do. (Kn.); 7. Scatophaga merdaria *F.*, do. (H. M.); 8. S. stercoraria *L.*, do. (H. M., Kn.); 9. Sepsis, freq., skg. (H. M.). (*d*) *Syrphidae*: 10. Eristalis arbustorum *L.*, skg. and po-dvg. (H. M.); 11. E. intricarius *L.*, do. (H. M.); 12. E. nemorum *L.*, do. (H. M.); 13. E. tenax *L.*, do (H. M., Kn.); 14. Rhingia rostrata *L.*, skg. (Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 15. Andrena albicans *Müll.* ♀ and ♂, skg. and po-cltg. (H. M., Kn.); 16. A. atriceps *K.* ♀ and ♂, skg. (H. M.); 17. A. dorsata *K.* ♀, po-cltg. (H. M.); 18. A. fasciata *Wesm.* ♂, skg. (H. M.); 19. A. fulva *Schrank* ♀, skg. and po-cltg. (H. M.); 20. A. fulvicrus *K.* ♀ and ♂, skg. (H. M.); 21. A. gwynana *K.* ♀, skg. and po-cltg. (H. M.); 22. A. parvula *K.* ♀, do. (H. M., Kn.); 23. A. eximia *Sm.* ♀, do. (H. M.); 24. A. schrankella *Nyl.* ♀, po-cltg. (H. M.); 25. Apis mellifica *L.* ☿, skg. and po-cltg. (H. M., Kn.); 26. Bombus lapidarius *L.* ♂, skg. (H. M.); 27. Halictus albipes *F.* ♀, freq., skg. and po-cltg. (H. M.); 28. H. cylindricus *F.* ♀, do. (H. M.); 29. Nomada succincta *Pz.* ♂, skg. (H. M.); 30. Osmia rufa *L.* ♂, do. (H. M.). (*b*) *Tenthredinidae*: 31. Dolerus gonager *Kl.*, skg. (H. M.). **D. Lepidoptera.** *Rhopalocera*: 32. Vanessa io *L.*, persistently skg. (H. M.).

Alfken noticed the following at Bremen.—

A. Diptera. (*a*) *Bombyliidae*: 1. Bombylius major *L.*, freq., skg. (*b*) *Muscidae*: 2. Sarcophaga carnaria *L.*, skg. (*c*) *Syrphidae*: 3. Eristalis arbustorum *L.*, very common, skg. and po-dvg.; 4. E. intricarius *L.*, do.; 5. Helophilus pendulus *L.*, do.; 6. Platycheirus albimanus *F.*; 7. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 8. Andrena albicans *Müll.* ♀ and ♂; 9. A. albicrus *K.* ♀ and ♂; 10. A. extricata *Sm.* ♀; 11. A. flavipes *Pz.* ♀; 12. A. helvola *L.* ♂; 13. A. nitida *Fourc.* ♀; 14. A. varians *K.* ♀ and ♂; 15. Apis mellifica *L.* ☿, very common, skg.; 16. Halictus flavipes *F.* ♀; 17. H. morio *F.* ♀; 18. H. nitidiusculus *K.* ♀; 19. Nomada alternata *K.* ♀; 20. N. lineola *Pz.* ♂, skg.; 21. N. succincta *Pz.* ♂; 22. Osmia rufa *L.* ♂. (*b*) *Tenthredinidae*: 23. Hoplocampa ferruginea *F.*; 24. H. rutilicornis *Klg.*

Gerstäcker records a bee, Osmia aurulenta *Pz.*, freq., for Berlin.

Schiner (Austria) noticed a hover-fly, Mallota fuciformis *F.*; and von Dalla Torre (Tyrol) a bee, Halictus smeathmanellus *K.* ♀ and ♂. Schletterer mentions the latter insect for the Tyrol, and observed the following bees at Pola.—1. Andrena carbonaria *L.*, freq.; 2. A. deceptoria *Schmiedekn.*; 3. A. theracica *F.*; 4. Bombus terrester *L.*; and a wasp, 5. Polistes gallica *L.*

Bees were observed by the following authorities in the localities stated.—

Schmiedeknecht (Thuringia).—1. Andrena congruens *Schmiedekn.*; 2. A. eximia *Sm.* Saunders (England), the rare Andrena bucephala *Steph.*, with its parasite, the beautiful Nomada xanthosticta *K.* Smith (England), Andrena bimaculata *K.*

827. P. Padus L. (Herm. Müller, 'Fertilisation,' pp. 221–2, 'Weit. Beob.,' II, p. 244; Knuth, 'Bloemenbiol. Bijdragen.')—The white, strongly fragrant blossoms of this species are arranged in many-flowered racemes, usually pendulous. Hermann Müller states that their mechanism agrees with that of P. spinosa in being protogynous; but the stamens remain curved somewhat inwards during the whole period of anthesis; so here self-pollination is more likely to be effected by insects during the second (hermaphrodite) stage. The inner stamens dehisce while they are curved down under the stigma, so that in becoming erect their anthers must brush against its edge. Automatic self-pollination must, therefore, regularly take place, should insect-visits fail.

Visitors. — On garden plants at Kiel I saw only Muscids as visitors of the flowers, which smell of trimethylamide.—1. Calliphora vomitoria *L.*; 2. Lucilia caesar *L.*; 3. Musca domestica *L.*; 4. Sarcophaga carnaria *L.*; all skg.

Herm. Müller observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Grammoptera ruficornis *F.*, nect-lkg. (*b*) *Malacodermata*: 2. Dasytes sp., nect-lkg. (*c*) *Mordellidae*: 3. Anaspis rufilabris *Gyll.*, nect-lkg. (*d*) *Nitidulidae*: 4. Meligethes, nect-lkg. **B. Diptera.** *Empidae*: 5. Empis livida *L.*, skg.; 6. E. rustica *Fall.*, do. **C. Hymenoptera.** *Apidae*: 7. Andrena parvula *K.* ♀, skg.

F. F. Kohl (Tyrol) saw the ruby wasp Ellampus aeneus *F.*

828. P. Mahaleb L.—This species also is slightly protogynous, according to Kirchner ('Neue Beob. ü. d. Bestäubungseinricht. einheimisch. Pfl.,' p. 37). At first the stamens are erect or inclined somewhat inwards, but subsequently the outer ones spread outwards. At the beginning of anthesis the style is of the same length as the shortest stamens, but later on attains that of the longest.

Visitors.—Schletterer observed three bees and a wasp at Pola.—

1. Andrena morio *Brull.*; 2. A. Thoracica *F.*; 3. Bombus argillaceus *Scop.*; 4. Polistes gallica *L.* (wasp).

244. Rosa Tourn.

Flowers homogamous, sometimes delightfully fragrant, usually large; rose-coloured, white, or more rarely yellow; devoid of nectar (some species, perhaps, have a thin layer on the edge of the receptacle). The lack of nectar is made up for by the abundant production of pollen.

829. R. canina L. (Herm. Müller, 'Fertilisation,' pp. 236–8, 'Weit. Beob.,' II, p. 239; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 307–8; Heinsius,

op. cit., iv, 1892, pp. 55–7; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins., pp. 70, 154.)—The bright pink fragrant flowers of this species are homogamous, and probably devoid of nectar. Hermann Müller says that the upper margin of the receptacle, internal to the insertion of the stamens, exhibits a thick fleshy ring, but this certainly does not appear to secrete any nectar. Heinsius describes this ring as having the structure of a nectary, the secretion, however, being so scanty that it is impossible to include the blossoms in the class of nectar-flowers. As the stamens curve outwards when the flower opens, and the petals remain tolerably erect, the ring just mentioned and the stigmas which project from the middle of it afford the most convenient alighting-place to insect visitors, and cross-pollination is in this way favoured. Should insect-visits fail, automatic self-pollination by the fall of pollen upon the stigmas takes place in all flowers, except such as happen to be quite erect.

VISITORS.—I saw the honey-bee, po-cltg., in the island of Amrum. MacLeod (Flanders) noticed a humble-bee, a Muscid, and 2 beetles (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 308, 380). Heinsius (Holland) records 3 hover-flies (Didea intermedia *Loew* ♀, Eristalis arbustorum *L.* ♀, E. horticola *Deg.* ♂), 2 Muscids (Anthomyia sp. ♂, Aricia vagans *Fall.* ♂), and a beetle (Cetonia metallica *F.* = C. floricola *Hbst.*) (op. cit., iv, 1892, p. 57).

Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.*, in the flowers (Budd.). (*b*) *Cerambycidae*: 2. Stenocorus inquisitor *F.* (H. M.); 3. Strangalia maculata *Poda* (H. M.). 4. S. nigra *L.*, gnawing the anthers and the delicate parts of the flowers in general (H. M.). (*c*) *Chrysomelidae*: 5. Luperus flavipes *L.* (H. M.). (*d*) *Cleridae*: 6. Trichodes alvearius *F.* ♀ (Budd.). (*e*) *Dermestidae*: 7. Anthrenus pimpinellae *F.*, freq., po-dvg. (H. M.); 8. A. scrophulariae *L.*, do. (H. M.). (*f*) *Mordellidae*: 9. Anaspis frontalis *L.* (H. M.); 10. Mordella aculeata *L.* (H. M.). (*g*) *Nitidulidae*: 11. Meligethes, freq. (H. M.). (*h*) *Scarabaeidae*: 12. Cetonia aurata *L.*, feeding on the stamens and stigmas, and biting large holes in the petals (H. M., Budd.); 13. Oxythyrea funesta *Poda*, do. (H. M.); 14. Phyllopertha horticola *L.*, do. (H. M.). (*i*) *Telephoridae*: 15. Anthocomus fasciatus *L.* (H. M.). **B. Diptera.** *Syrphidae*: 16. Helophilus floreus *L.*, po-dvg. (H. M.); 17. Syritta pipiens *L.*, freq., po-dvg. (H. M.). **C. Hymenoptera.** *Apidae*: 18. Andrena albicans *Müll.* ♀ and ♂, po-cltg. and po-dvg. (H. M.); 19. A. fucata *Sm.* ♀, po-cltg. (H. M.); 20. Apis mellifica *L.* ☿, do. (H. M.); 21. Halictus nitidus *Schenck* ♀, do. (H. M.); 22. Megachile circumcincta K. ♀, do. (H. M.); 23. Osmia rufa *L.* ♀, do. (H. M.); 24. Prosopis communis *Nyl.* ♀ and ♂, freq., po-dvg. (H. M.).

Schenck (Nassau) saw the bee Andrena labialis *K.* ♂; Redtenbacher (Vienna) the Chrysomelid Cryptocephalus duodecimpunctatus *F.*; von Dalla Torre and Schletterer (Tyrol) the bee Andrena propinqua *Schenck* ♀.

In Dumfriesshire Apis, freq., 3 humble-bees, a short-tongued bee, a ruby-wasp, a Tenthredinid, 2 Muscids, and 5 hover-flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 62).

830. R. repens Scop. (= R. arvensis *Huds.*).—The flowers of this species are white, fragrant, and devoid of nectar. Kirchner describes their mechanism as agreeing with that of R. canina. Kerner states the flowers are open from 4 a.m. till 9 p.m., and that anthesis lasts two days.

831. R. pimpinellifolia *L.* (= R. spinosissima *L.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 69–70, 154.)—I have been able to study the flower mechanism

of this species on the dunes, especially those of the island of Röm, but have had little opportunity of observing visitors there. The diameter of the white corolla is about 3 cm. Anthers and stigmas mature simultaneously when the flowers open. Although the stamens curve away from the stigmas, so that insects-visits render cross-pollination possible, yet automatic self-pollination takes place in the absence of these insects, for when, owing to the frequent violent winds on the islands, the little plant strikes against the ground pollen can easily be transferred to the adjacent stigmas.

VISITORS.—I saw several po-dvg. Muscids in the island of Röm, as well as Forficula and a few po-dvg. beetles.

Verhoeff (Norderney) observed a beetle (Phyllopertha horticola *L.*, freq., po-dvg.) and a humble-bee (Bombus terrester *L.*, a ☿, po-cltg.).

832. **R. rubiginosa** L. (Herm. Müller, 'Weit. Beob.,' II, pp. 239–40; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 70, 154.)—In this species not only the flowers but also the foliage-leaves are fragrant, so that the latter help to attract insects. The bright pink flowers afford them not only pollen, as in the other species of the genus, but also nectar, as shown by Hermann Müller. It is secreted in quite a thin layer on the broad fleshy margin of the receptacle. The flowers of this species are slightly protogynous, so that cross-pollination necessarily takes place when insects visit them at the beginning of anthesis. At this stage numerous fully mature stigmas are crowded together in the middle of the flower, as projecting pillow-like swellings, affording to insects a convenient alighting-place and platform. The stamens at this time are still curved outwards, and their anthers as yet unripe. Later on, when the anthers dehisce, the filaments bend together above the middle of the flower, so that automatic self-pollination takes place. Kerner states that the flowers are open from 5 a.m. till 9 p.m.

VISITORS.—In the island of Amrum I only observed the honey-bee, po-cltg.

Herm. Müller gives the following list.—

A. Coleoptera. (*a*) *Chrysomelidae*: Crytocephalus sericeus *L.*, devouring the flowers; 2. Luperus flavipes *L.*, freq. (*b*) *Telephoridae*: 3. Danacea pallipes *Pz.*, in very large numbers within the flowers. **B. Diptera.** *Stratiomyidae*: 4. Oxycera pulchella *Mg.*, occasional. **C. Hymenoptera.** *Apidae*: 5. Bombus pratorum *L.* ☿, po-cltg.; 6. B. terrester *L.* ☿, do.

833. **R. alpina** L.

VISITORS.—Herm. Müller ('Alpenblumen,' p. 215) saw a small bee (Halictus).

834. **R. centifolia** L. (Herm. Müller, 'Fertilisation,' pp. 237–8, 'Weit. Beob.,' II, p. 239'; Knuth, 'Bloemenbiol. Bijdragen.')

VISITORS.—I (Kn.) noticed that this and other cultivated double species received a moderately large number of visits; Herm. Müller (H. M.) records more numerous visitors for R. centifolia alone.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.*, destroying the delicate parts of the flowers, especially the anthers (H.M.); 2. Grammoptera ruficornis *F.*, very numerous, do. (H. M.); 3. Strangalia atra *Laich.*, as 1 (H. M.); 4. S. attenuata *L.*, do. (H. M.). (*b*) *Cistelidae*: 5. Cistela murina *L.*, as 1 (H. M.). (*c*) *Dermestidae*: 6. Anthrenus fuscus *Ltr.*, rare (H. M.); 7. A. pimpinellae *F.* (H. M.); 8. A. scrophu-

lariae *L.*, freq. (H. M.). (*d*) *Mordellidae*: 9. Anaspis ruficollis *F.*, as 1 (H. M.); 10. Mordella aculeata *L.*, do. (H. M.) (*e*) *Nitidulidae*: 11. Meligethes, in very large numbers (H. M., Kn.). (*f*) *Scarabaeidae*: 12. Cetonia aurata *L.*, devouring the flowers (H. M., Kn.); 13. Melolontha vulgaris *F.*, do. (H. M., Kn.); 14. Phyllopertha horticola *L.*, do. (H. M., Kn.). (*g*) *Telephoridae*: 15. Anthocomus fasciatus *L.*, freq. (H. M.); 16. Dasytes sp., rare (H. M.).

Kohl records a fossorial wasp, Crabro peltarius *Schreb.* ♀ and ♂.

835. **R. alba** L.—On bushes with double flowers in gardens at Vésztö (Hungary), Borbás observed 2–3 well-formed fruits containing seeds capable of germinating.

836. **R. pomifera** Herm.—

VISITORS.—The following bees were observed by von Dalla Torre and Schletterer in the Tyrol.—1. Halictus albipes *F.*; 2. H. interruptus *Pz.*; 3. H. tumulorum *L.*; 4. Osmia leucomelaena *K.*; 5. Prosopis sinuata, *Schenck* ♂.

245. Rubus L.

Flowers white or reddish in colour; homogamous, feebly protandrous, or feebly protogynous, sometimes dioecious (R. Chamaemorus); with concealed nectar abundantly secreted by a fleshy ring on the margin of the receptacle internal to the stamens.

The recognition of the numerous recently demarcated species of Rubus is in itself a special study, and perhaps later investigators will consider it necessary to distinguish between the flower mechanisms and visitors of the various species; though it is hardly likely that any important differences will make themselves apparent. For the purposes of Flower Pollination, in the meantime, one collective name will serve, i. e.—

837. **R. fruticosus** L. (Herm. Müller, 'Fertilisation,' pp. 227–8, 'Weit. Beob.,' II, pp. 240–1; Kirchner, 'Flora v. Stuttgart,' p. 451; Loew, 'Blütenbiol. Floristik,' p. 391; Knuth, 'Bl. u. Insekt. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen,' &c.)—In this species, according to Hermann Müller's account, the usually white petals spread out flat, so that conspicuousness is fairly marked. The stamens diverge so widely that even very short-tongued insects can easily thrust their heads between the filaments and carpels so as to reach the nectar-secreting ring in the base of the flower. The anthers of the outermost stamens dehisce first, and turn their pollen-covered sides upwards, while the stigmas mature simultaneously. It follows that most visitors effect crossing, so that, as a rule, the flowers are fertilized before all the anthers are ripe. Automatic self-pollination is rendered somewhat difficult, for only the dehisced anthers of the innermost stamens sometimes touch the outermost stigmas. It is only in the rarest cases, during continued bad weather, that self-pollination is resorted to, for otherwise insect-visits are extremely numerous.

VISITORS.—I have not observed in North Germany the species of Halictus which were seen by Buddeberg in large numbers in Nassau.

Herm. Müller (H. M.) and Buddeberg (Budd.) record the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.*, sometimes nect-lkg.,

sometimes dvg. the flowers (H. M.); 2. Leptura livida *F.*, do. (H. M.); 3. L. maculicornis *Deg.*, very numerous, in the flowers (H. M.); 4. Judolia cerambyciformis *Schr.*, do. (H. M.); 5. Strangalia armata *Hbst.*, do. (H. M.); 6. S. atra *Laich.*, do. (H. M.); 7. S. melanura *L.*, do. (H. M.); 8. S. nigra *L.*, do. (H. M.). (*b*) *Curculionidae*: 9. Spermophagus cardui *Stev.*, busy on the anthers (H. M.). (*c*) *Dermestidae*: 10. Byturus fumatus *F.*, skg., and dvg. the flowers (H. M.). (*d*) *Elateridae*: 11. Corymbites aeneus *L.*, dvg. the delicate parts of the flowers (H. M.); 12. Lacon murinus *L.* (H. M.); Limonius cylindricus *Payk.*, as 11. (*e*) *Mordellidae*: 13. Mordella aculeata *L.*, in the flowers (H. M., Thuringia). (*f*) *Nitidulidae*: 14. Meligethes, freq. (*g*) *Oedemeridae*: 15. Oedemera virescens *L.*, nect-lkg., and dvg. the delicate parts of the flowers (H. M.). (*h*) *Scarabaeidae*: 16. Phyllopertha horticola *L.*, grazing in the flowers (H. M.); 17. Trichius fasciatus *L.*, dvg. the delicate parts of the flowers (H. M.). (*i*) *Telephoridae*: 18. Cantharis rustica *Fall.*, as 17 (H. M.); 19. Malachius bipustulatus *L.*, do. (H. M.). **B. Diptera.** (*a*) *Conopidae*: 20. Physocephala rufipes *F.*, skg. (H. M.); 21. Sicus ferrugineus *L.*, do. (H. M.). (*b*) *Empidae*: 22. Empis livida *L.*, freq., skg. (H. M.); 23. G. tessellata *F.*, skg. (H. M.). (*c*) *Muscidae*: 24. Echinomyia grossa *L.*, skg. (H. M.); 25. Lucilia sp., do. (*d*) *Syrphidae*: 26. Ascia podagrica *F.*, skg. and po-dvg. (H. M.); 27. Chrysotoxum arcuatum *L.*, do. (H. M.; 28. Eristalis tenax *L.*, do. (H. M.); 29. Helophilus pendulus *L.*, do. (H. M.); 30. Rhingia rostrata *L.*, do. (H. M.); 31. Syritta pipiens *L.*, do. (H. M.); 32. Volucella inanis *L.*, skg. (Budd.); 33. V. pellucens *L.*, do. (H. M., Budd.). (*e*) *Stratiomyidae*: 34. Chrysomyia formosa *Scop.*, skg. (H. M.); 35. Sargus cuprarius *L.*, do. (H. M.). (*f*) *Tipulidae*: 36. Tipula oleracea *L.*, skg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 37. Andrena albicrus *K.* ♂, skg. (H. M.); 38. A. gwynana *K.* ♀, do. (H. M.); 39. A. thoracica *F.* ♀, do. (H. M.); 40. Apis mellifica *L.* ☿, very common, skg. and po-cltg. (H. M.); 41. Bombus agrorum *F.*, skg. and po-cltg. (H. M., Kn.); 42. B. hortorum *L.* ☿, do. (H. M.); 43. B. hypnorum *L.* ♂, freq., skg. (Kn.); 44. B. lapidarius *L.* ♂, skg. (Kn.); 45. B. pratorum *L.* ♀ and ♂, numerous, skg. (H. M.); 46. B. scrimshiranus *K.* ☿, skg. and po-cltg. (H. M.); 47. B. sylvarum *L.* ♀, do. (H. M.); 48. B. soroënsis *F.*, var. proteus *Gerst.*, freq., skg. (Kn.); 49. B. terrester *L.* ♀ and ♂, skg. and po-cltg. (H. M.); 50. Coelioxys elongata *Lep.* ♀ and ♂, skg. (Budd.); 51. C. rufescens *Lep.* ♀, dvg. (H. M.); ♂, do. (H. M., Budd.); 52. Diphysis serratulae *Pz.* ♀, do. (H. M.); 53. Halictus albipes *F.*, var. affinis *Schenck*, do. (H. M.); 54. H. cylindricus *F.* ♀ and ♂, do. (H. M.); 55. H. flavipes *F.* ♀. do. (Budd.); 56. H. leucopus *K.* ♀, do. (Budd.); 57. H. leucozonius *Schr.* ♀, po-cltg. (H. M.); 58. H. lucidulus *Schenck* ♀, skg. (H. M.); 59. H. malachurus *K.* ♀, do. (Budd.); 60. H. quadricinctus *K.* ♀, do. (Budd.); 61. H. sexnotatus *K.* ♀, do. (H. M., Budd.); 62. H. smeathmanellus *K.* ♀, do. (Budd.); 63. H. villosulus *K.* ♀, skg. and po-cltg. (H. M., Budd.); 64. H. zonulus *Sm.* ♀, skg. (H. M.); 65. Macropis labiata *Pz.* ♂, do. (H. M.); 66. Nomada fabriciana *L.* ♀, do. (H. M.); 67. N. lateralis *Pz.* ♀, do. (H. M.); 68. N. lineola *Pz.* ♂, do. (H. M.); 69. N. ruficornis *L.* ♂, do. (H. M.); 70. Osmia fusca *Chr.* ♀, do. (H. M.); 71. Prosopis communis *Nyl.* ♂, do. (H. M.); 72. P. pictipes *Nyl.* ♂, do. (H. M.); 73. P. variegata *F.* ♂, do. (H. M.); 74. Psithyrus campestris *Pz.* ♀, do. (H. M.); 75. P. quadricolor *Lep.* ♂, do. (H. M., Kn.); 76. P. vestalis *Fourcr.* ♀, do. (H. M.); 77. Stelis breviuscula *Nyl.* ♂, do. (H. M.). (*b*) *Formicidae*: 78. Formica pratensis *Deg.* ☿, nect-lkg. (H. M.); 79. F. sp., skg. (Kn.). (*c*) *Sphegidae*: 80. Ammophila campestris *Ltr.* ♂, skg. (H. M.); 81. A. hirsuta *Scop.*, nect-lkg. (H. M.); 82. A. sabulosa *L.* ♀ and ♂, skg. (H. M.); 83. Cerceris quinquefasciata *Rossi* ♂, do. (H. M.); 84. C. rybiensis *L.* ♀, nect-lkg. (Budd.); 85. Crabro peltarius *Schreb.* ♀ and ♂, skg. (H. M.); 86. Oxybelus uniglumis *L.* ♀ and ♂, do. (H. M.). **D. Lepidoptera.** *Rhopalocera*: 87. Argynnis paphia *L.*, skg. (H. M.); 88. Epinephele janira *L.*, do. (H. M.); 89. Erebia ligea *L.*, freq., skg. (H. M.); 90. Carterocephalus palaemon *Pall.*, skg. (H. M.); 91. Melithaea athalia *Esp.*, freq., skg. (H. M.); 92. Pieris crataegi *L.*, skg. (H. M.); 93. P. napi *L.*, do. (H. M.); 94. Thecla ilicis *Esp.*, do. (Budd.).

The following bees were recorded as stated.—

Schenck (Nassau), 1. Andrena florea *F.*; 2. A. trimmerana *K.*; 3. Coelioxys conoidea *Ill.* ♀; 4. Halictus albipes *F.* ♀; 5. H. calceatus *Scop.* ♀; 6. H. morio *F.*; 7. H. pauxillus *Schenck* ♀ and ♂; 8. H. sexnotatus *K.* Schletterer (Tyrol), Bombus variabilis *Schmiedekn.* von Dalla Torre (Tyrol), B. muscorum *F.* ☿.

Kohl (Tyrol) records a fossorial wasp (Crabro peltarius *Schreb.* ♀ and ♂), and a ruby-wasp (Hedychrum nobile *Scop.*).

Loew observed the following in Silesia ('Beiträge,' pp. 33, 51).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *F.*, nect-lkg.; 2. L. maculicornis *Deg.*, do.; 3. Strangalia bifasciata *Müll.*, do. (*b*) *Malacodermata*: 4. Dasytes flavipes *F.*, nect-lkg. (*c*) *Nitidulidae*: 5. Meligethes sp. **B. Diptera.** (*a*) *Muscidae*: 6. Dexia rustica *F.*, skg. (*b*) *Syrphidae*: 7. Eristalis intricarius *L.*, skg.; 8. E. tenax *L.*, do.; 9. Helophilus floreus *L.*, do.; 10. H. pendulus *L.*, do.; 11. Syrphus grossulariae *Mg.*, do.; 12. Volucella bombylans *L.*, do.; 13. V. pellucens *L.*, do. **C. Hymenoptera.** *Apidae*: 14. Bombus pratorum *L.* ♂, skg.; 15. B. scrimshiranus *K.* ♂, do.; 16. B. soroënsis *F.*, var. B. proteus *Gerst.* ♂, do.; 17. Diphysis serratulae *Pz.* ♂, do.; 18. Macropis labiata *Pz.* ♂, do. **D. Lepidoptera.** *Rhopalocera*: 19. Argynnis paphia *L.*; 20. Coenonympha arcania *L.*; 21. Hesperia comma *L.*; 22. Lycaena argiolus *L.*; 23. Melitaea parthenie *Bkh.*; 24. Epinephele janira *L.*; 25. Pieris brassicae *L.*; 26. Polyommatus alciphron *Rott.*; 27. Vanessa prorsa *L.* All skg.

Loew further noticed 2 bees in Mecklenburg—1. Prosopis confusa *Nyl.* ♂, skg.; 2. P. sp., do. (op. cit., p. 41): and 2 bees in Switzerland—1. Andrena propinqua *Schenck* ♀, skg.; 2. A. thoracica *F.* ♀, do. (op. cit., p. 60).

I saw the following in the island of Rügen.—

A. Diptera. (*a*) *Muscidae*: 1. Aricia sp. (*b*) *Syrphidae*: 2. Eristalis pertinax *Scop.*; 3. E. tenax *L.*; 4. Syrphus ribesii *L.*; 5. Volucella bombylans *L.* ♀, and the var. plumata *Mg.* **B. Hymenoptera.** (*a*) *Apidae*: 6. Apis mellifica *L.*; 7. Bombus agrorum *F.* ♀; 8. B. lapidarius *L.* ☿; 9. B. terrester *L.* ♀; 10. Psithyrus quadricolor *Lep.* ♂. (*b*) *Sphegidae*: 11. Ammophila sabulosa *L.* ♂. **C. Lepidoptera.** *Rhopalocera*: 12. Argynnis paphia *L.*, and the var. valesina *Esp.*; 13. Epinephele janira *L.*; 14. Limenitis sibylla *L.*; 15. Pieris sp. All freq., skg.

Gerstäcker noticed the following bees in Berlin.—

1. Osmia acuticornis *Duf. et Perr.*; 2. O. leucomelaena *K.*; 3. O. uncinata *Gerst.*

Alfken and Höppner (H.) observed the following at Bremen.—

A. Diptera. (*a*) *Asilidae*: 1. Dioctria oelandica *L.* ♀ and ♂. (*b*) *Syrphidae*: 2. Sericomyia borealis *Fall.*; 3. Volucella pellucens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Andrena albicans *Müll.* ♀; 5. A. albicrus *K.* ♀; 6. A. tibialis *K.* ♀; 7. Bombus agrorum *F.* ♀ and ☿; 8. B. lucorum *L.* ☿; 9. B. pratorum *L.* ♂; 10. B. proteus *Gerst.* ♀; 11. B. sylvarum *L.* ♀; 12. Eriades truncorum *L.* ♂; 13. Halictus calceatus *Scop.* ♀; 14. H. levis *K.* ♀; 15. Macropis labiata *K.* ♀ and ♂; 16. Megachile circumcincta *K.* ♂; 17. Nomada mutabilis *Mor.* ♀ (H.); 18. N. ochrostoma *K.* ♀; 19. N. roberjeotiana *Pz.* ♂ (H.); 20. N. similis *Mor.* ♀ (H.); 21. Prosopis bipunctata *F.* ♀; 22. P. communis *Nyl.* ♀ and ♂; 23. P. confusa *Nyl.* ♀; 24. P. dilatata *K.* ♀; 25. P. hyalinata *Sm.* ♀; 26. P. nigrita *F.* ♀; 27. P. pictipes *Nyl.* ♀; 28. P. rinki *Gorski*, ♂. (*b*) *Sphegidae*: 29. Crabro subterraneus *F.* ♀.

Visitors were recorded as follows by the authorities and at the places named.—

Hoffer (Steiermark), the bee Bombus hypnorum *L.* ☿. Schiner (Dalmatia), the Therevid Xestomyza Kollari *Egg.* Friese (Hungary), 2 bees, 1. Andrena albopunctata *Rossi*, 2. A. fucata *Sm.*; (Baden) the bee Bombus jonellus *K.*

MacLeod observed Apis, 7 humble-bees, 7 short-tongued bees, a Tenthredinid, 5 hover-flies, 6 other flies, 4 beetles, and 10 Lepidoptera in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 318–19); and 3 bees, a Lepidopterid, a beetle, and a hover-fly in the Pyrenees (op. cit., iii, 1891, p. 432).

H. de Vries saw a bee, Halictus cylindricus *F.* ♀, in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

Willis observed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes viridescens *F.*, freq., skg. and po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia radicum *L.*, freq. (*b*) *Syrphidae*: 3. Eristalis pertinax *Scop.*, freq., skg.; 4. Platycheirus albimanus *F.*, skg.; 5. Syrphus balteatus *Deg.*, po-dvg.; 6. S. topiarius *Mg.*, skg. **C. Hymenoptera.** *Apidae*: 7. Bombus agrorum *L.*, freq., skg.; 8. B. hortorum *L.*, do. **D. Lepidoptera.** (*a*) *Microlepidoptera*: 9. Simaëthis oxyacanthella *L.*, freq., skg. (*b*) *Rhopalocera*: 10. Pieris napi *L.*, freq., skg.

Saunders (Sd.) and Smith (Sm.) record the following bees for England.—

1. Andrena austriaca *Pz.* (= A. rosae *Saund.*) (Sd., Sm.); 2. A. bimaculata *K.* (= A. decorata *Sm.*, and A. vitrea *Sm.*), 2nd generation (Sd., Sm.); 3. A. carbonaria

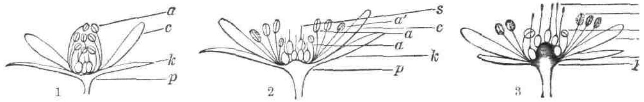


FIG. 110. *Rubus caesius, L.* (Diagrammatic longitudinal sections of flowers, magnified about 2 diameters. Föhr, July, 1892.) 1. Flower before the beginning of the first stage: all the anthers are closed and incline together above the equally immature styles; the receptacle is flat. 2. Flower in the *beginning of the male stage: the anthers of the outer stamens (which have now curved away from* the centre are ripe; the stigmas are not yet fully mature; the receptacle has begun to bulge. 3. Flower in the hermaphrodite stage: most of the stamens have curved away from the centre, and their anthers are ripe; only a few remain immature with filaments curved under the fully developed stigmas, which are at *the ends of the elongated styles; the receptacle is distinctly dome-shaped. p*, receptacle; *k*, sepal; *c*, petal; *a*, immature anther; *a'*, mature anther; *s*, stigma.

L. (= A. pilipes *F.*), 2nd generation (Sd.); 4. A. dorsata *K.* (Sd., Sm.); 5. Halictus sexnotatus *K.* ♂ (Sm.); 6. Prosopis bipunctata *F.* (= P. signata *Pz.*) (Sd.); 7. P. communis *Nyl.* (Sd.); 8. P. confusa *Nyl.* (Sd.); 9. P. hyalinata *Sm.* (Sd., Sm.).

Marquard (Cornwall) saw 2 bees, 1. Andrena austriaca *Pz.*; 2. A. minutula *K.*

838. **R. caesius.** (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 66–7, 154, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 233.)—When the flowers of this species open the anthers are all immature, and lie above the middle of the flower with the filaments inclining inwards. Subsequently the outer stamens bend back towards the petals, and their anthers dehisce. As dehiscence progresses centripetally the originally flat receptacle becomes more and more convex, the styles begin to grow, and the stigmas appear at their tips. Several series of stamens with dehisced anthers have meanwhile bent back towards the petals, while those with undehisced anthers remain with their filaments curved under the stigmas. When insects visit the flower and alight in its centre cross-pollination is effected, but if they alight elsewhere self-pollination results. The latter takes place automatically when the inner stamens erect themselves, for they dehisce directly upon the stigmas.

VISITORS.—I observed the following in the island of Föhr.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes sp. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp. ♀; 3. Drymeia hamata *Fall.*; 4. Lucilia caesar *L.*; 5. L. sp.; 6. Musca sp.; 7. Onesia sepulcralis *Mg.*; 8. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 9. Eristalis arbustorum *L.*; 10. Helophilus floreus *L.* ♀; 11. H. pendulus *L.*; 12. Syrphus ribesii *L.* **C. Hymenoptera.** *Apidae*: 13. Apis mellifica *L.*; 14. Bombus lapidarius *L.*; 15. B. terrester *L.*; 16. Coelioxys acuminata *Nyl.*; 17. C. rufescens *Lep.*; 18. Colletes picistigma *Thoms.*; 19. Megachile centuncularis *L.* ♀. **D. Lepidoptera.** *Rhopalocera*: 20. Epinephele janira *L.*; 21. Lycaena semiargus *Rott.* To these must be added a fossorial wasp, 22. Ammophila sabulosa *L.*, noticed in 1897 in the island of Amrum, though not previously seen by me on the North Frisian Islands: all skg.

Alfken observed the following in Juist.—

A. Diptera. (*a*) *Stratiomyidae*: 1. Sargus cuprarius *L.* (*b*) *Syrphidae*: 2. Syrphus trilineatus *L.* **B. Hymenoptera.** *Apidae*: 3. Bombus lucorum *L.* ☿, freq., skg.; 4. B. muscorum *F.* ☿, do.; 5. B. terrester *L.* ☿, do.; 6. Colletes marginatus *L.* ♀, freq., po-cltg. and skg.; 7. Megachile maritima *K.* ♀, skg. and po-cltg., ♂ skg.

Verhoeff saw a small Muscid in Norderney.

Schenck noticed the following bees in Nassau.—

1. Ceratina cyanea *K.*; 2. Macropis labiata *F.*, and the var. fulvipes *F.*; 3. Stelis breviuscula *Nyl.*

Schletterer observed the following **Hymenoptera** at Pola.—

(*a*) *Apidae*: 1. Bombus variabilis *Schmiedekn.*; 2. Eucera interrupta *Baer.*; 3. Halictus minutus *K.*; 4. H. morbillosus *Krchb.*; 5. H. quadricinctus *F.*; 6. H. scabiosae *Rossi*; 7. H. variipes *Mor.*; 8. Osmia aurulenta *Pz.*; 9. Prosopis genalis *Ths.* (*b*) *Sphegidae*: 10. Tachysphex nitidus *Spin.*

H. de Vries observed, in the Netherlands, 2 humble-bees (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875),—Bombus subterraneus *L.* ☿, and B. terrester *L.* ☿.

839. **R. odoratus** L. (Knuth, 'Bloemenbiol. Bijdragen.') — This is a Canadian species, often cultivated in German gardens as an ornamental shrub. The flower mechanism is as follows.—At first the numerous still unripe anthers completely cover the immature stigmas; those of the outer stamens then dehisce, and *pari passu* the stigmas become freed by an increase in the diameter of the flower. An insect dusted with pollen will therefore necessarily effect crossing if it alights in the middle of the flower, and when such an insect creeps to the mature peripheral anthers it covers its under-surface with pollen afresh. Dehiscence of the anthers goes on centripetally, so that the pollen of the innermost may effect automatic self-pollination by falling upon the stigmas should insect-visits fail. In spite of the large size of the flower (40–50 mm. in diameter), and of the deep red colour of the petals, the number of visitors is small. Automatic self-pollination is not always effective in Germany, for I have very rarely observed the setting of fruits.

VISITORS.—I have seen Bombus lapidarius *L.* ♂, po-cltg., in the island of Rügen. Loew has noticed a humble-bee in Silesia ('Beiträge,' p. 51); also B. hypnorum *L.* , skg., in the Berlin Botanic Garden.

840. **R. Idaeus** L. (Herm. Müller, 'Fertilisation,' pp. 226–7; Kirchner, 'Flora v. Stuttgart,' pp. 450–1; Knuth, 'Bl. u. Insekt. a. d. Ins. Rügen.') — In the flowers of this species the small narrow petals, which Kerner says drop off on the second day of anthesis, remain erect, according to Hermann Müller's account, so

that the stamens are crowded together between them and the carpels, and hence a nectar-seeking insect can only insert its proboscis into the receptacle. This mostly results in cross-pollination, for the styles are generally made use of as an alighting-place. Automatic self-pollination regularly takes place, for some of the stigmas always come into contact with the anthers.

VISITORS.—I saw the following in the island of Rügen: all freq., skg.—

A. Diptera. (*a*) *Muscidae*: 1. Lucilia caesar *L.*; 2. Scatophaga merdaria *L.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. E. pertinax *Scop.*; 5. E. sepulcralis, *L.*; 6. E. tenax *L.*; 7. Helophilus floreus *L.* ♂; 8. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 9. Bombus lapidarius *L.* ☿; 10. B. terrester *L.* ♀ and ☿. **C. Lepidoptera.** *Rhopalocera*: 11. Pieris sp.

Alfken observed the following at Bremen.—

A. Coleoptera. (*a*) *Trixagidae*: 1. Trixagus fumatus *F.*, freq. (*b*) *Cerambycidae*: 2. Strangalia nigra *L.*, very common. **B. Diptera.** (*a*) *Empidae*: 3. Empis tessellata *F.*, very common. (*b*) *Syrphidae*: 4. Ascia podagrica *F.*; 5. Syrphus ribesii *L.* **C. Hymenoptera.** (*a*) *Apidae*: 6. Andrena albicans *Müll.* ♀; 7. A. albicrus *K.* ♀; 8. A. fucata *Sm.* ♀, freq., skg., po-cltg.; 9. A. fulvida *Schenck* ♀, rare, skg. and po-cltg.; 10. A. nigroaenea *K.* ♀; 11. A. parvula *K.* ♀; 12. Apis mellifica *L.*; 13. Bombus agrorum *F.* ♀ and ☿; 14. B. derhamellus *K.* ♀, skg. and po-cltg.; 15. B. hortorum *L.* ☿, skg.; 16. B. jonellus *K.* ☿, do.; 17. B. lapidarius *L.* ♀, po-cltg. and skg.; 18. B. lucorum *L.* ♀ and ☿; 19. B. muscorum *F.*, skg. and po-cltg.; 20. B. pratorum *L.* ☿ and ♂, do.; 21. B. proteus *Gerst.* ♀ and ☿, po-cltg., ♂ skg.; 22. B. sylvarum *L.* ♀; 23. B. terrester *L.* ♀, skg. and po-cltg.; 24. Coelioxys quadridentata *L.* ♂, skg.; 25. C. elongata *Lep.* ♂; 26. C. rufescens *Lep.* ♂, skg.; 27. Eriades florisomnis *L.* ♀ and ♂; 28. E. truncorum *L.* ♂; 29. Halictus calceatus *Scop.* ♀; 30. H. leucopus *K.* ♀; 31. H. levis *K.* ♀; 32. H. minutus *K.* ♀; 33. H. punctulatus *K.* ♀; 34. H. quadrinotatulus *Schenck* ♀; 35. H. tumulorum *L.* ♀; 36. Megachile centuncularis *L.* ♀; 37. Prosopis communis *Nyl.* ♂; 38. P. confusa *Nyl.* ♀; 39. Psithyrus rupestris *F.* ♀, skg. (*b*) *Ichneumonidae*: 40. Mesostenus ligator *Gr.*, skg. (*c*) *Vespidae*: 41. Odynerus antilope *Pz.* ♂; 42. O. parietum *L.* ♀ and ♂; 43. Vespa sylvestris *Scop.* ♀.

Schenck (Nassau) saw 2 bees (Andrena fucata *Sm.*, and A. varians *K.*) and a wasp (Vespa norwegica *F.*, one ♀).

Handlirsch records the fossorial wasp Gorytes mystaceus *L.*

von Fricken noticed the following **Coleoptera** in Westphalia and East Prussia.—

(*a*) *Nitidulidae*: 1. Cychramus luteus *Oliv.* (*b*) *Byturidae*: 2. Byturus fumatus *F.*, very freq. (*c*) *Malacodermata*: 3. Dasytes niger *L.*, not rare. (*d*) *Curculionidae*: 4. Anthonomus rubi *Hbst.*, freq.

Herm. Müller observed the following in Westphalia.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Pachyta octomaculata *F.*, freq., nect-lkg. and dvg. the flowers. (*b*) *Dermestidae*: 2. Byturus fumatus *L.*, dvg. the anthers and nect-lkg. **B. Diptera.** *Syrphidae*: 3. Rhingia rostrata *L.*, skg. and po-dvg.; 4. Volucella pellucens *L.*, do. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 5. Andrena albicrus *K.* ♂, skg. (H. M.); 6. A. nigroaenea *K.* ♂, do.; 7. Apis mellifica *L.* ☿, extremely common, skg. and po-cltg.; 8. Bombus agrorum *F.* ♀, freq., skg.; 9. B. hortorum *L.* ♀, po-cltg.; 10. B. pratorum *L.* ☿ and ♂, freq., skg. and po-cltg.; 11. B. muscorum *F.* ♀, skg.; 12. B. sylvarum *L.* ♀, do.; 13. Halictus lucidulus *Schenck* ♀, do. (*b*) *Tenthredinidae*: 14. Macrophya rustica *L.*

Herm. Müller saw a hover-fly, 7 bees, a wasp, and a Lepidopterid in the Alps ('Alpenblumen,' p. 215).

Loew (Silesia) saw a wasp, Vespa media *Retz.* ♀, skg. ('Beiträge,' p. 33); and Warnstorf (Brandenburg) numerous bees and humble-bees. MacLeod (Flanders) noticed 5 long-tongued bees, 4 short-tongued bees, 2 wasps, an ant, 3 hover-flies, 5 other flies, 5 beetles, and a few Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 317). Plateau (Belgium) saw Apis, Bombus hypnorum *L.*, B. lapidarius *L.*; and also numerous moths, e.g. Scoliopterys libatrix *L.*

In Dumfriesshire, Apis (common), 3 humble-bees, and 2 hover-flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 55).

Morawitz gives a bee, Nomada ochrostoma *K.*, for St. Petersburg.

Friese observed 2 bees in Mecklenburg: 1. Andrena fucata *Sm.*, freq.; 2. A. fulvida *Schenck*, rare.

Hoffer gives the following bees for Steiermark.—

1. Bombus agrorum *F.* ♀ and ☿; 2. B. hypnorum *L.* ☿, occasional; 3. B. pratorum, *L.* ♀ and ☿, very common, ♂; 4. B. terrester *L.* ♂.

Schmiedeknecht, on the authority of S. Brauns, records Bombus jonellus *K.* ♂.

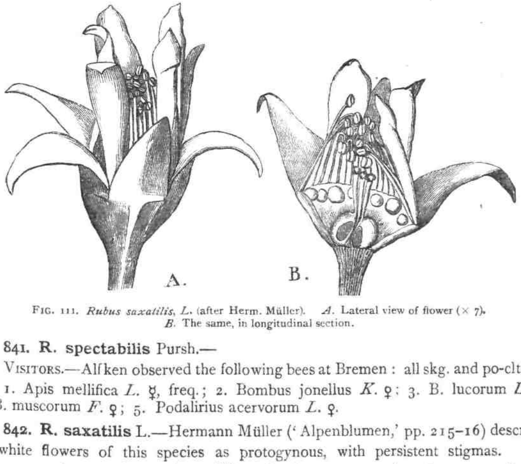


FIG. 111. *Rubus saxatilis, L.* (after Herm. Müller). *A.* Lateral view of flower (× 7). *B.* The same, in longitudinal section.

841. **R. spectabilis** Pursh.—

VISITORS.—Alfken observed the following bees at Bremen: all skg. and po-cltg.—

1. Apis mellifica *L.* ☿, freq.; 2. Bombus jonellus *K.* ♀; 3. B. lucorum *L.* ♀; 4. B. muscorum *F.* ♀; 5. Podalirius acervorum *L.* ♀.

842. **R. saxatilis** L.—Hermann Müller ('Alpenblumen,' pp. 215–16) describes the white flowers of this species as protogynous, with persistent stigmas. The stamens are about 40 in number. When the flowers open the stigmas are already mature: the outer stamens now become erect, and their anthers dehisce, while the inner ones remain curved inwards, so that the stigmas are for a time protected against automatic self-pollination. As the petals incline together above the nectar-secreting receptacle only a small passage of access is left. Visitors at first effect cross-pollination, subsequently self-pollination as well. The latter always takes place automatically should insect-visits fail (Müller, Warming).

VISITORS.—Herm. Müller observed 3 bees and an Empid in Switzerland.

843. R. Chamaemorus L.—This species is dioecious. The white flowers appear to be visited but seldom, as fruits are rarely seen. According to Warming, propagation is largely effected by underground shoots. Vahl says that in some parts of Greenland female plants alone occur, and in other parts only males. This statement is confirmed by Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 18). Such an arrangement is intelligible as a result of the marked vegetative reproduction.

In Spitzbergen the species is usually sterile. Female flowers only were seen there in bloom (7. 8. '83 and 23. 7. '98), but no fruits were observed (Andersson and Hesselman, loc. cit.).

Schulz states that female flowers with almost normal stamens are found in the Riesengebirge.

VISITORS.—Schneider observed the humble-bees Bombus alpinus *L.* and B. scrimshiranus *K.* in Arctic Norway (Mus. Aars. Tromsø, xvii, 1895).

In Dumfriesshire an Empid and 3 Muscids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 57).

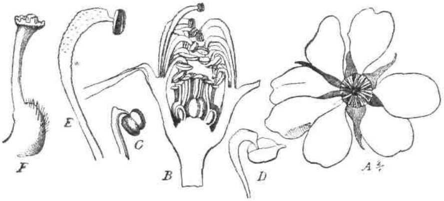


FIG. 112. *Rubus arcticus, L.* (after E. Warming). *A.* A flower seen from above. *B.* Longitudinal section through a flower; the outermost anthers are ripe. *C, D, E.* Stamens of different series. *E.* An outermost one. *F.* A carpel.

844. R. arcticus L.—According to Warming's investigations at Bosekop (Norway) the dark rose-red stellate flowers of this species are slightly protandrous ('Arkt. Växt. Biol.,' pp. 37–40). The outer anthers dehisce early, and the stamens are more closely crowded together above the stigmas than in other species of the genus, so that automatic self-pollination necessarily takes place. Propagation is chiefly effected by subterranean shoots.

845. R. serpens Weihe.—

VISITORS.—Loew saw Apis (skg. and po-cltg.) in the Berlin Botanic Garden.

246. Dryas L.

Flowers white; protogynous, homogamous, or protandrous; with concealed nectar, secreted by a fleshy ring internal to the insertion of the stamens. Not rarely androdioecious or andromonoecious.

846. D. octopetala L. (Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Herm. Müller, 'Alpenblumen,' pp. 227–8; Schulz, 'Beiträge'; Lindman, 'Bidrag till Känned. om Skandin. Fjällväxt Blomn. o. Befrukt.'; Warming, 'Arkt. Växt. Biol.')—

In this species, besides the hermaphrodite flowers described by Ricca, A. Schulz, and Lindman as protogynous, and by Hermann Müller as functionally protandrous, there are unisexual ones distributed androdioeciously (Müller), or andromonoeciously (Schulz), and these male flowers are on an average smaller than those which are hermaphrodite. Failing insect-visits, pollen must fall upon the stigmas from the stamens (which almost reach their level) owing to the oblique position of the flowers, so that automatic self-pollination results. On the other hand, owing to the projection of the stigmas, crossing is usually effected by such visits.

Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 381) describes the flowers as protogynous, and gives the following account of their mechanism.—The stamens, which curve inwards in the bud, straighten themselves only a short time before the anthers dehisce. The anthers of the outermost whorls dehisce first, so that to begin with autogamy is excluded owing to the distance between stigmas and anthers. At this stage insect visitors which alight in the middle of the flower and creep outwards to collect pollen or lick nectar effect cross-pollination. The inner stamens now straighten themselves, and their anthers dehisce. These are now at the same level as the stigmas, which are still receptive, and consequently get self-pollinated. This is favoured by the outward inclination of the external carpels. The automatic self-pollination of the stigmas of the inner carpels, should insect-visits fail, is brought about at the end of anthesis by the bending of the peduncle to an extent that brings them into the line of fall of the pollen.

On the Dovrefjeld, Lindman noticed protogyny followed by homogamy, but not dioecism. Warming, on the other hand, observed that in Greenland the flower mechanism is the same as in Europe. Ekstam gives 10–25 mm. for the diameter of the odourless, homogamous flowers examined in Nova Zemlia. Automatic self-pollination is possible.

The species flowers in Spitzbergen from the end of June to the end of August, or even longer, and sometimes sets numerous fruits (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 20–1). Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' p. 10) says that the flowers there are faintly fragrant, and 20–7 mm. (exceptionally 28–38 mm.) in diameter. Self-pollination can easily take place, for the anthers dehisce almost immediately over the stigmas. The peduncle elongates considerably after anthesis.

The variety *unguiculata*, discovered by Nathorst, possesses a form of flower which deviates markedly from the ordinary type, for the petals narrow at their bases into a claw 4 mm. long, and radiate squarrosely, while the petals are bent inwards (Andersson and Hesselman, op. cit.).

According to Abromeit, the flowers of the variety *intermedia* Nathorst, which unites the group-forms D. octopetala *L.* and D. integrifolia *Vahl*, exhibit slight protogyny and slight protandry, as well as homogamy ('Bot. Ergeb. von Drygalsky's Grönlandsexped.').

Visitors.—Herm. Müller saw in the Alps numerous bees (especially Halictus sp.), and Diptera (particularly Muscids), as well as some beetles and Lepidoptera. Frey (Switzerland) noticed the Tineids Ergatis heliacella *H.-S.*, and Tinagma dryadis *Stgr.*

von Dalla Torre (Tyrol) saw the bee Halictoides dentiventris *Nyl.* ♀, and Schletterer records the same visitor.

Lindman (Dovrefjeld) observed 2 species of flies; and Holmgren (Spitzbergen) Hymenoptera (Hemiteles septentrionalis *Holmgr.*, and Orthocentrus pedestris *Holmgr.*) and Diptera (Aricia (Spilogaster) dorsata *Zett.*, A. (Chortophila) megastoma *Bohem.*, and Scaeva dryadis *Holmgr.*).

Ekstam noticed several small and medium-sized flies in Nova Zemlia. MacLeod saw a short-tongued bee, a hover-fly, and a Muscid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 427).

847. D. integrifolia Vahl.—Warming observed this species in Greenland, and states that both hermaphrodite and male flowers occur there ('Bestövningsmaade af

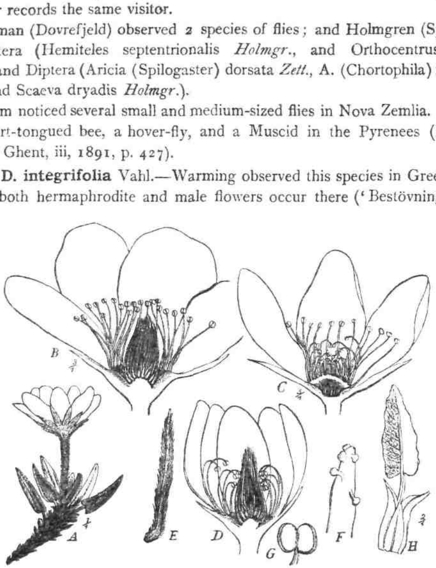


FIG. 113. *Dryas integrifolia, Vahl* (from Greenland: after E. Warming). *A.* Entire plant (× 4/5). *B.* Hermaphrodite flower. *C.* Male flower. *D.* Protogynous hermaphrodite flower. *E.* A carpel. *F.* Tip of a style with germinating pollen-grains. *G.* Anther. . *H.* A foliage-leaf.

nogle grönlandske Blomst.,' pp. 127–8). The hermaphrodite flowers are homogamous or slightly protogynous, or even slightly protandrous: automatic self-pollination can readily take place. (Cf. Fig. 113.)

247. Geum L.

Flowers yellow; protogynous or rarely homogamous; with concealed nectar secreted in the receptacle. Sometimes androdioecious or andromonoecious.

848. G. rivale *L.* (Herm. Müller, 'Fertilisation,' p. 229; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Loew, 'Blütenbiol. Floristik,' p. 390; Schulz, 'Beiträge,' I, pp. 33–4; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bloemenbiol. Bijdragen.')—In the flowers of this species the calyx is brownish-red, and the petals bright yellow streaked with red; nectar is secreted in numerous drops in the receptacle. According to Hermann Müller, the hermaphrodite flowers are slightly protogynous: at first the mature stigmas project beyond the still unripe

anthers, so that at this stage cross-pollination must result from insect-visits. The stamens now elongate, bringing the pollen-covered anthers to the level of the outer stigmas, so that when the flower closes automatic self-pollination is readily effected.

Insect visitors usually hang on to the flowers from below, by means of the second and third legs, and thrust their heads and first legs into them. Some humble bees, especially Bombus terrester *L.*, also steal nectar from the outside, without rendering any service in return. The proboscis is inserted between the calyx and petals.

A. Schulz states that, besides hermaphrodite flowers, there are unisexual ones, distributed androdioeciously or andromonoeciously. These male flowers are of the same size as the ordinary kind. There is a group of vestigial carpels in the middle of the stamens. Warnstorf also observed andromonoecism and androdioecism, the male flowers, however, being much smaller than the others. He describes the pollen-grains as being of a beautiful yellow colour, very irregular, roundish, tetrahedral or ovoid, slightly tuberculated, up to 43 μ long and 25 μ broad. Warnstorf also states that the flowers are very frequently visited and robbed by humble-bees.

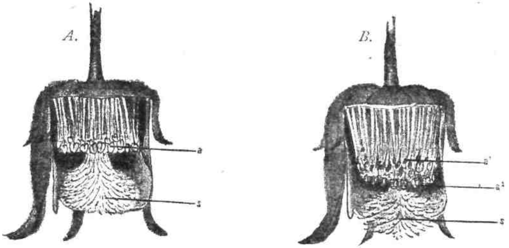


FIG. 114. *Geum rivale, L.* (from nature; enlarged). *A.* Flower (after removal of the anterior sepals and petals) in the first stage, with stigmas (*s*) mature, and anthers (*a*) still unripe. *B.* The same, in the second stage, with stigmas still receptive, and anthers partly dehisced (a^2), partly still unripe (a^1).

VISITORS.—Herm. Müller (H. M.) in Westphalia, Loew (L.) in Brandenburg, and myself (Kn.) in Schleswig-Holstein observed the following.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes, freq., completely covered with pollen (H. M., Kn.). **B. Diptera.** *Syrphidae*: 2. Eristalis nemorum *L.*, po-dvg. (Kn.); 3. Rhingia rostrata *L.*, skg. and po-dvg. (H. M., Kn.). **C. Hymenoptera.** *Apidae*: 4. Andrena helvola *L.* ♀, vainly seeking for nectar (H. M.); 5. Apis mellifica *L.* ☿, freq., skg. from the outside (H. M., L., Kn.); 6. Bombus agrorum *F.* ♀, skg. (H. M., L., Kn.); 7. B. confusus *Schenck* ♀, do. (H. M.); 8. B. distinguendus *Mor.* ♀, very occasionally, skg. (H. M.); 9. B. hortorum *L.* ♀ and ☿, very common, skg. (H. M.); 10. B. hypnorum *L.* ♀, skg. (H. M.); 11. B. lapidarius *L.* ♀, do. (H. M., L., Kn.); 12. B. pratorum *L.* ♀, do., ☿ also po-cltg. (H. M.); 13. B. scrimshiranus *K.* ☿ and ♀, skg. (H. M.); 14. B. muscorum *F.* ♀, do. (H. M.); 15. B. sylvarum *L.* ♀, freq., skg. and po-cltg. (H. M.); 16. B. terrester *L.* ♀, skg. (H. M.).

Herm. Müller saw 2 humble-bees in the Alps ('Alpenblumen,' p. 227).

Gerstäcker observed Osmia bicolor *Schr.* ♀, po-cltg., at Berlin.

In Dumfriesshire 2 humble-bees and a hover-fly (very common) were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 54).

Schneider saw Bombus hypnorum *L.* ☿ and ♀ in Arctic Norway (Mus. Aarsh. Tromsø, xvii, 1895).

849. G. urbanum L. (Herm. Müller, 'Fertilisation,' p. 230; Schulz, 'Beiträge,' I, p. 34, II, p. 186; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 66.)—In the much smaller golden-yellow flowers of this species, according to Hermann Müller, nectar is secreted by a green fleshy ring situated internal to the filaments. When the flower opens, the stamens are curved inwards, so that the anthers lie close to the outer carpels, while the inner stigmas are mature and project from the middle of the flower. The outermost stamens at once begin to curve outwards, their anthers dehisce, and turn their pollen-covered sides upwards; the more central stamens then do the same. The innermost ones almost always shed some of their pollen upon the outermost stigmas. Cross-pollination is therefore assured by early insect-visits, and even later is favoured by the position of the stigmas. Usually, however, automatic self-pollination comes into play, the number of visitors being very small owing to the time of flowering, and because the flowers are associated with many others that are more conspicuous.

Schulz states that, besides hermaphrodite flowers, there are also male ones distributed andromonoeciously or more rarely androdioeciously. The same investigator observed large-flowered and small-flowered forms; the former as a rule markedly protogynous, the latter homogamous. The two are connected by intermediate stages.

Visitors.—Herm. Müller observed the following.—

A. Coleoptera. *Dermestidae*: 1. Byturus fumatus *F.*, po-dvg. **B. Diptera.** *Syrphidae*: 2. Melithreptus scriptus *L.*, skg. and po-cltg.

I saw the humble-bee Bombus terrester *L.* ☿, skg., in Kiel (20. 6. '97).

MacLeod observed a Muscid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 310).

Verhoeff noticed the following in Norderney.—

A. Coleoptera. *Malacodermata*: 1. Dasytes plumbeus *Müll.*, po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Aricia incana *Wiedem.*, a ♀. (*b*) *Syrphidae*: 3. Melanostoma mellina *L.*, a ♀, po-dvg.

In Dumfriesshire 4 muscids were recorded (Scott-Elliott, 'Flora of Dumfriesshire,' p. 54).

850. G. reptans L. (Herm. Müller, 'Alpenblumen,' pp. 225–6.)—The hermaphrodite flowers of this species are markedly protogynous. They grow to such an extent during anthesis that the original diameter of 12–15 mm. is increased to 30–35 mm. Kerner states that there are two forms of the hermaphrodite flowers, one with short and the other with long stamens. Besides these flowers there are others, which have become purely male by degeneration of the carpels. They occur either on stocks of their own or are associated with hermaphrodite flowers.

851. G. montanum L. (Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Schulz, 'Beiträge,' I, p. 33; Herm. Müller, 'Alpenblumen,' pp. 226–7.) — The mechanism of this species agrees with that of G. reptans, but the flowers are usually

somewhat smaller. Here again Kerner distinguished two forms. Besides the hermaphrodite flowers, there are also unisexual ones distributed androdioeciously and andromonoeciously (Schulz).

Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 381) states that the flowers behave like those of Dryas octopetala (q. v.), so that at first cross-pollination is favoured; subsequently they become autogamous.

Visitors.—Herm. Müller observed in the Alps numerous Diptera (especially Syrphidae and Muscidae), as well as some bees, Lepidoptera, and beetles. MacLeod saw 3 Hymenoptera and 4 Diptera in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 427).

852. **G. coccineum** Sibth. et Sm.—The flower mechanism of this species agrees with that of G. montanum.

Visitors.—Loew observed the bee Halictus nitidiusculus *K.* ♀, po-cltg., in the Berlin Botanic Garden.

853. **G. japonicum** Thunbg.—

Visitors.—Loew saw the bee Halictus sexnotatus K. ♀, po-cltg., in the Berlin Botanic Garden.

854. **G. inclinatum** Schleich.—

Visitors.—Loew saw the honey-bee Apis mellifica *L.* ☿, among the stamens, skg., in the Berlin Botanic Garden.

248. Waldsteinia Willd.

Flowers protogynous, with concealed nectar, secreted just below the insertions of the stamens at the upper margin of the top-shaped receptacle.

855. **W. geoides** Willd. (Loew, 'Blütenbiol. Beiträge,' I, pp. 14–16.)—This species ranges from Galicia and the Siebengebirge to the Crimea. The nectar is covered by small heart-shaped plates that project at an acute angle from the bases of the stamens. The flower mechanism is similar to that of Geum rivale.

Visitors.—Loew saw a small bee (Halictus nitidiusculus *K.*) and a flower-fly (Anthomyia), both skg., in the Berlin Botanic Garden.

856. **W. trifolia** Koch. (Loew, op. cit.)—This species belongs to the Siebengebirge and Siberia. Its flower mechanism is similar to that of W. geoides, but nectar-covers are wanting.

857. **W. fragarioides** Tratt.—The flower mechanism of this North American species agrees with that of W. trifolia.

Visitors.—Loew (op. cit.) observed the same insects as in W. geoides.

249. Fragaria L.

Flowers white, protogynous, with concealed nectar. This is secreted by a narrow fleshy ring on the receptacle, which is covered by the outer carpels from within, and the stamens from without. Unisexual flowers are also present.

858. **F. vesca** L. (Herm. Müller, 'Fertilisation,' pp. 230–1, 'Weit. Beob., II, p. 241, 'Alpenblumen,' p. 216; Schulz, 'Beiträge,' II, p. 187; Millardet, Mém. Soc.

sci. phys. nat., Bordeaux, Ser. 4, iv, 1894; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller was the first to describe the mechanism of the protogynous hermaphrodite flowers of this species. The petals spread out flat, and therefore offer to insects a convenient alighting-place and platform. As the anthers dehisce long after the stigmas mature, insects probing down to the nectar-ring usually effect cross-pollination. In the absence of visits, automatic self-pollination generally takes place, owing to the oblique position of the flower. Schulz observed gynomonoecism and gynodioecism, as well as andromonoecism and androdioecism. Darwin says that in the United States, among the numerous cultivated varieties of the strawberry, plants of three kinds are recognized by growers, i.e. 1. female, which produce fruits in great abundance; 2. hermaphrodite, which yield a scanty crop; 3. male, which of course set no fruits. Such forms may also be recognized among plants cultivated in Germany, but purely male individuals are rare.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Grammoptera ruficornis *F.*, not infrequent, nect-lkg., and dvg. the anthers; even when pairing the ♀ continues to gnaw an anther (H. M.). (*b*) *Dermestidae*: 2. Anthrenus pimpinellae *F.*, nect-lkg. (H. M.); 3. A. scrophulariae *L.*, do. (H. M.). (*c*) *Telephoridae*: 4. Dasytes flavipes *F.*, nect-lkg. and dvg. the anthers (H. M.); 5. Malachius bipustulatus *L.*, do. (H. M.). (*d*) *Mordellidae*: 6. Mordella aculeata *L.*, nect-lkg. (H. M.). (*e*) *Nitidulidae*: 7. Meligethes, freq. (H. M.). **B. Diptera.** (*a*) *Empidae*: 8. Empis chioptera *Fall.*, skg. (H. M.); 9. E. livida *L.*, do. (H. M.); (*b*) *Muscidae*: 10. Anthomyia sp. (H. M.); 11. Musca corvina *F.* (H. M.); 12. Scatophaga merdaria *Fall.*, skg. (H. M.). (*c*) *Syrphidae*: 13. Eristalis sepulcralis *L.*, skg. (H. M.); 14. Melithreptus menthastri *L.*, do. (H. M.); 15. Paragus bicolor *F.*, skg. and po-dvg. (Budd.); 16. Rhingia rostrata *L.*, skg. (H. M.); 17. Syritta pipiens *L.*, freq., skg. (H. M.); 18. Syrphus sp., skg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 19. Andrena dorsata *K.* ♀, po-cltg. (H. M.); 20. Apis mellifica *L.* ☿, do. (H. M.); 21. Halictus leucopus *K.* ♀, skg. and po-cltg. (Budd.); 22. H. lucidulus *Schenck* ♀, skg. (H. M.); 23. H. sexstrigatus *Schenck* ♀ (H. M.); 24. Nomada ruficornis *L.* ♀, skg. (H. M.); 25. N. ruficornis *L.*, var. signata *Jur.* ♂, skg. (H. M.); 26. N. sexfasciata *Pz.* ♂ (H. M.); 27. Prosopis communis *Nyl.* ♀ (H. M.). (*b*) *Formicidae*: 28. Myrmica levinodis *Nyl.* ☿, nect-lkg. (H. M.). (*c*) *Sphegidae*: 29. Oxybelus uniglumis *L.*, nect-lkg. (H. M.). **D. Thysanoptera.** 30. Thrips, freq., skg. (H. M.).

Herm. Müller saw 6 Hymenoptera, 2 beetles, 8 flies, and a bug in the Alps.

Alfken noticed a Syrphid (Pipiza sp.), freq., at Bremen.

Friese observed the bee Osmia caerulescens *L.*, not rare, in Mecklenburg; and Schenck the following bees in Nassau.—

1. Andrena flessae *Pz.*; 2. Halictus albipes *F.* ♀; 3. H. calceatus *Scop.*; 4. H. morio *F.*; 5. Osmia bicolor *Schr.*

MacLeod (Pyrenees) saw an ant and a beetle (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 432); and (Flanders) a short-tongued bee, 2 Muscids, an Empid, and 4 beetles (op. cit., vi, 1894, pp. 312, 380).

In Dumfriesshire, a hover-fly and 2 Muscids were recorded (Scott-Elliott, 'Flora of Dumfriesshire,' p. 57).

In the Berlin Botanic Garden, on the var. semperflorens *Hayne*, Loew observed 2 Syrphids (Eristalis aeneus *Scop.*, skg., and Syritta pipiens *L.*, po-cltg.).

859. F. elatior Ehrh. (=F. moschata *Duchesne*).—The mechanism of the flowers of this species, according to Kirchner ('Flora v. Stuttgart,' p. 442), agrees with that of F. vesca. Schulz ('Beiträge,' II, p. 187), observed andromonoecism and androdioecism, rarely gynodioecism and gynomonoecism. The species is sporadically purely dioecious, in some places there are only male-pleogamous or female-pleogamous stocks, while elsewhere 10 % or more of the flowers are hermaphrodite.

VISITORS.—Herm. Müller observed beetles, a wasp, a Lepidopterid, a Bombylius, and 4 hover-flies in the Alps ('Alpenblumen,' p. 216). Loew noticed a Syrphid (Chrysogaster coemeteriorum *L.*), skg., in the Berlin Botanic Garden.

860. F. collina Ehrh. (=F. viridis *Duchesne*).—The yellowish-white flowers of this species are imperfectly dioecious; pseudo-hermaphrodite plants usually predominate. Schulz ('Beiträge,' II, p. 187) observed androdioecism and gynodioecism, and also andromonoecism and gynomonoecism. Kirchner ('Flora v. Stuttgart,' p. 441) states that the male and female flowers differ in size; in the former the stamens are twice as long as the group of carpels, in the latter the anthers (which do not dehisce) are at the same level.

VISITORS.—Loew observed 2 Syrphids (Eristalis nemorum *L.*, po-dvg., and E. sepulcralis *L.*) in the Berlin Botanic Garden.

250. Comarum L.

Dark purple-red protandrous flowers, with nectar half- or completely concealed and secreted in the usual place.

861. C. palustre L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 67–8, 154, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234.)—The flowers of this species are about $2\frac{1}{2}$ cm. in diameter, and secrete abundant nectar from a green ridge-like disk situated between the stamens and the carpels. The large sepals are dark purple-red to almost brown internally, while the much smaller petals are rather brighter in colour. The anthers dehisce laterally some time after the perianth has unfolded. The stamens, which number about twenty and are in two whorls, are at first erect, the inner anthers being above the carpels, so that pollen must fall upon the stigmas. As these are still immature, however, such self-pollination is not effective. After the anthers have fallen off, the filaments bend back towards the perianth, leaving the space they occupied in the middle of the flower free for the styles. These meanwhile increase in length, and their tips are beset with small yellow papillae. It follows that insect-visits must effect crossing, while automatic self-pollination is excluded, even when some of the pollen remains adhering to the stigmas.

After fertilization has been effected the broad sepals shut together above, and with them the small (5 mm. long, $1\frac{1}{2}$ mm. broad) pointed petals, so that the opening of the flower is closed, and the less conspicuous reddish-green outer surfaces of the sepals once more become visible (as in the bud). The epicalyx remains perpendicular to the peduncle. Warnstorf describes the pollen-grains as yellowish in colour, smooth, spherical, and 25–31 μ in diameter.

Visitors.—In the island of Röm I saw the honey-bee, skg., and Muscids (especially Aricia lardaria *F.*) at Kiel. In the island of Föhr I observed another Muscid (Nemoraea consobrina *Mg.*), as well as a Lepidopterid (Epinephele janira *L.*).

Heinsius noticed the following in Holland.—

A. Diptera. (*a*) *Muscidae*: 1. Aricia incana *Wied.* ♂; 2. Lucilia caesar *L.* ♂; (*b*) *Stratiomyidae*: 3. Odontomyia viridula *F.* ♂ and ♀; (*c*) *Syrphidae*: 4. Eristalis pertinax *Scop.* ♀; 5. Helophilus lineatus *F.* ♂; 6. Tropidia milesiformis *Fall.* ♀. **B. Hymenoptera.** *Apidae*: 7. Bombus scrimshiranus *K.* ☿. **C. Lepidoptera.** *Rhopalocera*: 8. Epinephele janira *L.* (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, p. 65).

Schneider saw Bombus nivalis *Dahlb.* ☿ in Arctic Norway (Mus. Aars. Tromsø, xvii, 1895).

251. Potentilla L.

Flowers usually homogamous, yellow or white, with half-concealed nectar, secreted as a rule only as a thin, annular, shining layer on the inner wall of the receptacle, and not forming actual drops.

862. P. Anserina L. (Herm. Müller, 'Fertilisation,' p. 233, 'Weit. Beob.,' II, p. 242; Schulz, 'Beiträge,' II, pp. 187–8; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 68, 154.)—Hermann Müller describes the yellow flowers of this species as homogamous, but Schulz says that they may also be slightly protandrous or slightly protogynous. The former states that there is a thin layer of nectar on the annular part of the inner wall of the receptacle that surrounds the roots of the filaments, and is of a dark or sometimes reddish-yellow colour. Insect visitors sometimes alight in the centre, sometimes upon the petals. In the former case, they effect cross-pollination; in the latter, they often do not touch the stigmas (which are then too near the middle), but only the anthers, that are covered all over with pollen. In dull weather the flowers are half shut, and during the night close completely, so that automatic self-pollination necessarily takes place if insect-visits fail.

Schulz also observed gynomonoecism and gynodioecism.

Visitors.—I saw 2 flies (Eristalis and Anthomyia) in the island of Föhr, and one (Eristalis arbustorum *L.* ♂, po-dvg.) in the island of Rügen.

Wüstnei noticed Andrena pilipes *Fbr.* in the island of Alsen.

Herm. Müller observed the following, of which the short-tongued bees were commonest.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes, freq. (*b*) *Staphylinidae*: 2. Tachyporus sp., nect-lkg. (*c*) *Telephoridae*: 3. Dasytes sp., nect-lkg. **B. Diptera.** *Muscidae*: 4. Anthomyia sp. ♀, skg.; 5. Scatophaga merdaria *F.*, do. **C. Hemiptera.** 6. Aphanus vulgaris *Schill.*, skg. **D. Hymenoptera.** (*a*) *Apidae*: 7. Apis mellifica *L.* ☿, skg.; 8. Halictus flavipes *F.* ♀, po-cltg.; 9. H. sexstrigatus *Schenck* ♀, do.; 10. H. zonulus *Sm.* ♀, skg.; 11. Sphecodes gibbus *L.*, do. (*b*) *Formicidae*: 12. Lasius niger *L.* ☿, nect-lkg. (*c*) *Sphegidae*: 13. Oxybelus bellus *Dahlb.*; 14. O. uniglumis *L.*

Herm. Müller also observed Bombus terrester, po-cltg., in the Alps ('Alpenblumen,' p. 221); and von Dalla Torre saw two bees in the Tyrol—1. Andrena proxima *K.* ♂; 2. Melecta luctuosa *Scop.* ♀. The latter is recorded by Schletterer for the same region.

Loew noticed the Syrphid Pyrophaena rosarum *F.*, skg., in Silesia ('Beiträge, p. 30).

Verhoeff observed the following in Norderney.—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes aeneus *F.* (*b*) *Staphylinidae*: 2. Tachyporus hypnorum *L.* **B. Diptera.** (*a*) *Empidae*: 3. Hilara quadrivittata *Mg.*, skg. (*b*) *Muscidae*: 4. Anthomyia sp., freq., skg. and po-dvg.; 5. Aricia incana *Wiedem.* ♂, skg. and po-dvg.; 6. Calliphora erythrocephala *Mg.*; 7. Cyrtoneura hortorum *Fall.* ♂, po-dvg.; 8. Lucilia caesar *L.* ♀ and ♂, skg.; 9. Myospila meditabunda *F.*; 10. Scatophaga stercoraria *L.* ♂; 11. Sepsis cynipsea *L.* (*c*) *Syrphidae*: 12. Cheilosia sp. ♀; 13. Chrysogaster macquarti *Löw* ♀; 14. Eristalis arbustorum *L.* ♀, skg.; 15. E. intricarius *L.*; 16. Helophilus pendulus *L.* ♀; 17. Melithreptus menthastri *L.* ♀, po-dvg.; 18. Pipizella virens *F.* ♂; 19. Platycheirus clypeatus *Mg.* ♂, skg.; 20. P. peltatus *Mg.* ♂; 21. Syrphus ribesii *L.* (*d*) *Therevidae*: 22. Thereva anilis *L.* ♂. **C. Hymenoptera.** (*a*) *Apidae*: 23. Andrena albicans *Müll.* ♀, skg. and po-cltg.; 24. Colletes cunicularius *L.* ♀, do.; 25. Osmia maritima *Friese.* (*b*) *Chrysididae*: 26. Holopyga ovata *Dahlb.* (*c*) *Formicidae*: 27. Formica fusca *L.* ☿, skg.; 28. Lasius niger *L.* ☿, do. **D. Lepidoptera.** *Lycaenidae*: 29. Polyommatus phlaeas *L.*

Leege noticed the following in Juist.—

A. Diptera. *Syrphidae*: 1. Volucella bombylans *L.*, very common. **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena albicans *Müll.* ♂, freq., skg.; 3. A. albicrus *K.* ♀, freq., skg. and po-cltg.; 4. Colletes cunicularius *L.*, rare; 5. Halictus rubicundus *Chr.* ♀, once; 6. Nomada ruficornis *L.* ♂, do.; 7. Prosopis brevicornis *Nyl.* ♂, rare. (*b*) *Sphegidae*: 8. Ammophila sabulosa *L.*, rare, skg.

MacLeod saw 3 Muscids in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 313).

In Dumfriesshire several Diptera were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 59).

863. **P. Wiemanniana** Guenth. Grab. et Wimm. (= P. Guentheri *Pohl*).—

Visitors.—F. F. Kohl observed the ruby-wasp Chrysis dichrora *Klg.* in the Tyrol.

864. **P. reptans** L. (Herm. Müller, 'Fertilisation,' pp. 232–3, 'Weit. Beob.,' II, p. 241; Schulz, 'Beiträge,' II, pp. 187–8; 'Knuth, 'Bloemenbiol. Bijdragen.')—The flower mechanism of this species agrees with that of P. Anserina. Schulż noticed gynomonoecism and gynodioecism.

Visitors.—I only observed Volucella bombylans *L.* and Meligethes.

Herm. Müller gives the following list, partly after Buddeberg (Budd.).—

A. Coleoptera. 1. Notoxys monoceros *L.*, in the flowers in large numbers. **B. Diptera.** (*a*) *Empidae*: 2. Empis livida *L.*, skg. (Thuringia). (*b*) *Muscidae*: 3. Aricia sp., skg. (Thuringia). (*c*) *Syrphidae*: 4. Eristalis arbustorum *L.*, skg. (Thuringia); 5. Syritta pipiens *L.*, skg. and po-dvg. (Thuringia); 6. Syrphus arcuatus *Fall.*, po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 7. Andrena albicrus *K.* ♂; 8. A. nana *K.* ♂, skg.; 9. Halictus cylindricus *F.* ♀, do.; 10. H. flavipes *F.* ♀, skg. and po-cltg. (Budd.); 11. H. leucozonius *Schr.* ♀, po-cltg.; 12. H. maculatus *Sm.* ♀ and ♂, skg. and po-cltg.; 13. H. sexstrigatus *Schenck* ♀, do.; 14. H. tetrazonius *Klg.* ♀ and ♂, do. (Thuringia, Budd.); 15. Nomada flavoguttata *K.* ♀, skg. (Budd.); 16. N. succincta *Pz.* ♂, do.; 17. N. xanthosticta *K.* ♂, do.; 18. Prosopis hyalinata *Sm.*, do.; 19. Sphecodes gibbus *L.* ♂, do. (*b*) *Sphegidae*: 20. Ammophila sabulosa *L.* ♂; 21. Oxybelus bellus *Dahlb.*, nect-lkg.

MacLeod (Flanders) observed 2 hover-flies and a Muscid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 313), and (Pyrenees) a Muscid (op. cit. iii, 1891, p. 431).

In Dumfriesshire, Dolichopodids, a Muscid, and 2 hover-flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 59).

865. P. sylvestris Neck. (= P. Tormentilla *Neck.* and Tormentilla erecta *L.*). (Herm. Müller, 'Fertilisation,' pp. 233–4, 'Weit. Beob.,' II, p. 242; Loew, 'Blütenbiol. Floristik,' p. 393; Schulz, 'Beiträge,' I, p. 35; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234.)—The flower mechanism of this species agrees with that of P. Anserina, but Hermann Müller says that nectar is secreted more abundantly, and the anthers are only covered with pollen on their narrow external edges, and not all over. Schulz states that the flowers, even of the same plant, are partly homogamous, partly protogynous, and partly slightly protandrous. They vary in size, as do the stamens in number, and there is also considerable variation in the pistil.

VISITORS.—Herm. Müller gives the following list.—

A. Diptera. (*a*) *Bombyliidae*: 1. Systoechus sulphureus *Mikan.*, skg. (*b*) *Syrphidae*: 2. Cheilosia sp., po-dvg.; 3. Chrysotoxum bicinctum *L.*, in large numbers; 4. Melithreptus scriptus *L.*, po-dvg. **B. Hymenoptera.** *Apidae*. 5. Andrena argentata *Sm.* ♀, po-dvg.; 6. A. denticulata *K.* ♀ and ♂, skg. and po-cltg.; 7. A. parvula *K.* ♀, po-cltg. **C. Lepidoptera.** *Rhopalocera*: 8. Pieris rapae *L.*, skg.

Herm. Müller also saw 2 Lepidoptera, a Muscid, and a beetle in the Alps ('Alpenblumen,' p. 222).

In the island of Föhr I noticed a bee, Andrena tibialis *K.* ♀, skg.

Loew saw a Leptid (Leptis sp.) and 2 Syrphids (Syrphus cinctellus *Zett.*, and Didea intermedia *Loew*, skg.) in Silesia ('Beiträge,' pp. 30, 49).

Alfken and Höppner (H.) give the following list of bees for Bremen.—

1. Andrena shawella *K.* ♀, po-cltg. and skg.; 2. A. tarsata *Nyl.* (H.); 3. Dufourea vulgaris *Schenck* (H.); 4. Nomada jacobaeae *Pz.* ♀ and ♂; 5. N. obtusifrons *Nyl.* ♀ and ♂; 6. N. solidaginis *Pz.* ♀ and ♂.

Verhoeff saw the following in Norderney.—

A. Diptera. (*a*) *Dolichopodidae*: 1. Dolichopus sp. (*b*) *Syrphidae*: 2. Melithreptus taematus *Mg.*, a ♂, po-dvg. **B. Hymenoptera.** *Apidae*: 3. Colletes cunicularis *L.*, a ♀, po-cltg.

MacLeod observed (Flanders) 7 short-tongued bees, 2 other short-tongued Hymenopterids, 3 Syrphids, 4 Muscids, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 314); also (Pyrenees) 2 Syrphids and 2 Muscids (op. cit., iii, 1891, p. 432).

In Dumfriesshire a humble-bee, a short-tongued bee, and several flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 58).

Willis and Burkill ('Fls. and Insects in Gt. Britain,' Part I) observed the following in Central Wales.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia radicum *L.*, skg.; 2. Lucilia cornicina *F.*, do.; 3. Siphona geniculata *Deg.*, do. (*b*) *Syrphidae*: 4. Eristalis horticola *L.*, skg.; 5 Sphaerophoria scripta *L.*, do. **B. Lepidoptera.** *Rhopalocera*: 6. Polyommatus phlaeas *L.* .

And for the neighbourhood of the south coast of Scotland they record.—

A. Coleoptera. *Scarabaeidae*: 1. Aphodius contaminatus *Herbst.*, resting on the flowers. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia radicum *L.*, very freq., skg. and po-dvg.; 3. Cyrtoneura curvipes *Meg.*, skg.; 4. Hydrellia griseola *Fall.*, po-dvg.; 5. Hylemyia lasciva *Zett.*, do.; 6. Oscinis frit *L.*, do. (*b*) *Syrphidae*: 7. Sphaerophoria scripta *L.*, po-dvg.; 8. Syritta pipiens *L.*, do.

866. P. argentea L. (Herm. Müller, 'Weit. Beob.,' II, p. 242; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 154.)—

VISITORS.—I only observed Meligethes in the island of Sylt, but bees and flies are the actual pollinators. Herm. Müller (H. M.) in Thuringia, and Buddeberg (Budd.) in Nassau, observed the following.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia quadripunctata *L.* (H. M.); 2. Coraebus elatus *F.* (H. M.). (*b*) *Nitidulidae*: 3. Meligethes, nect-lkg. (H. M.). **B. Diptera.** (*a*) *Muscidae*: 4. Anthomyia sp. ♀, freq., skg. (H. M.); 5. Aricia sp., skg. (H. M.); 6. Ulidia erythrophthalma *Mg.*, in large numbers, skg. (H. M.). (*b*) *Syrphidae*: 7. Paragus bicolor *F.*, skg. (Budd.). **C. Hymenoptera.** (*a*) *Apidae*: 8. Andrena dorsata *K.* ♀, skg. and po-cltg. (Budd.); 9. Halictus leucopus *K.* ♀, skg. (Budd.); 10. H. maculatus *Sm.* ♀, do. (H. M.); 11. H. morio *F.* ♀, do. (Budd.); 12. H. villosulus *K.* ♀, skg. and po-cltg. (Budd.); 13. Nomada fabriciana *L.* ♀, skg. (Budd.); 14. Prosopis communis *Nyl.* ♀, do. (H. M.); 15. Stelis breviuscula *Nyl.* ♀, do. (H. M.). (*b*) *Evaniidae*: 16. Foenus affectator *F.*, nect-lkg. (H. M.).

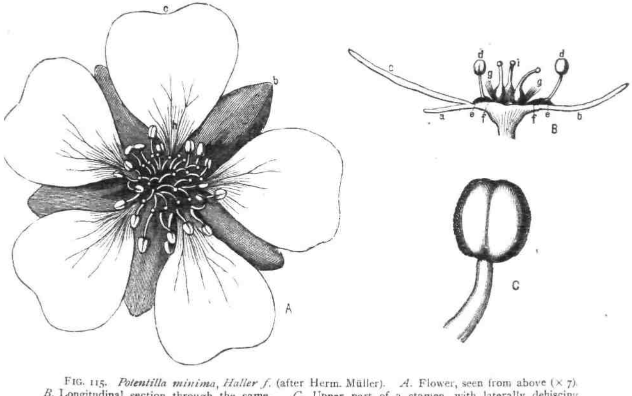


FIG. 115. *Potentilla minima*, *Haller f.* (after Herm. Müller). *A.* Flower, seen from above (× 7). *B.* Longitudinal section through the same. *C.* Upper part of a stamen, with laterally dehiscing anther (× 35). *a*, epicalyx; *b*, calyx; *c*, corolla; *d*, stamen; *e*, yellow nectar-secreting fleshy ring, into which the stamens are inserted; *f*, inner orange-coloured part of this ring, on which a layer of nectar is found; *g*, ring of hairs by which nectar is secreted; *h*, orange-coloured blotch at base of petal (nectar-guide); *i*, carpel.

867. P. procumbens Sibth.—

VISITORS.—MacLeod noticed 3 hover-flies and a Siricid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 313–14); and Verhoeff saw a Sphegid (Oxybelus uniglumis *L.*, skg.), in Norderney.

868. P. minima Hall. f. (Herm. Müller, 'Alpenblumen,' p. 217.)—The small yellow blossoms of this species are homogamous, but at the beginning of anthesis the petals are not quite fully expanded, so that the middle of the flower is the most convenient alighting-place, and visitors which come dusted with pollen from an older flower may effect either cross- or self-pollination. Failing insect-visits, automatic

self-pollination takes place, and this would frequently appear to be resorted to, for Hermann Müller only observed 2 Muscids and a micro-Lepidopterid as visitors. (Cf. Fig. 115.)

VISITORS.—*Vide supra.*

869. **P. salisburgensis** Haenke (= P. alpestris *Hall.* and P. maculata *Pourr.*). (Herm. Müller, 'Alpenblumen,' p. 218.)—The flowers of this species agree as regards their mechanism with those of P. minima, but are larger, so that insect visitors are more numerous.

VISITORS.—Herm. Müller observed 8 Muscids, 7 Syrphids, 2 beetles, 3 bees, and 3 Lepidopterids. (Cf. P. verna.)

MacLeod noticed a short-tongued bee, a Syrphid, and a Muscid in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 431).

In Dumfriesshire an Empid and 2 Muscids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 58).

870. **P. aurea** L. (Herm. Müller, 'Alpenblumen,' pp. 218–19; Schulz, 'Beiträge,' II, p. 68; Loew, 'Blütenbiol. Floristik,' p. 397.)—The flowers agree in mechanism with those of P. salisburgensis, but are still larger, so that the visitors are still more numerous. Schulz observed gynomonoecism and gynodioecism, and according to him the hermaphrodite flowers in the Riesengebirge are slightly protogynous.

VISITORS.—Herm. Müller observed 18 Muscids, 8 hover-flies, 3 beetles, 7 bees, and 15 Lepidopterids; and Loew noticed 2 hover-flies, a Muscid, a Lepidopterid, and a beetle.

Loew records the following for Switzerland ('Beiträge,' p. 57).—

A. Coleoptera. *Malacodermata*: 1. Dasytes alpigradus *Kiesew.* **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp. (*b*) *Syrphidae*: 3. Cheilosia brachysoma *Egg.* (?); 4. Pelecocera scaevoides *Fall.* **C. Lepidoptera.** *Zygaenidae*: 5. Zygaena exulans *Hchw.*

871. **P. frigida** Vill.—The flower mechanism of this Alpine species, according to Kirchner ('Beiträge,' p. 39), agrees essentially with that of P. minima, though the corolla does not spread out flat, but is saucer-shaped. Hence the diameter of the flower is only 7–10 mm., although each of the yellow petals is 5 mm. long. The base of each petal is marked with an orange-yellow blotch. The flowers are homogamous: dehiscence of the anthers begins externally, and continues centripetally, so that at the beginning of anthesis cross-pollination is more readily effected by insect-visits than in P. minima. Later on, when the anthers of the inner stamens have dehisced, automatic self-pollination is inevitable.

872. **P. multifida** L.—The flowers of this Alpine species agree as regards their mechanism (Kirchner, loc. cit.) with those of P. frigida, but all the anthers are ripe at the beginning of anthesis. As they are close to the stigmas automatic self-pollination is inevitable.

Plants with buds, flowers, and ripe fruits were found (6. 8. '82) at Cape Thordsen in Spitzbergen (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 20).

Visitors.—Loew (Jahrb. Kgl. bot. Gart. zu Berlin, iv, 1886, p. 159) observed a po-dvg. hover-fly (Eristalis sepulcralis *L.*) on cultivated plants in the Berlin Botanic Garden.

873. **P. supina** L.—This species agrees with P. Anserina as regards its flower mechanism, and the occurrence of gynomonoecism and gynodioecism (Schulz, 'Beiträge,' II, p. 187).

874. **P. recta** L.—Kerner states that the flowers of this species open between 11 and 12 o'clock in the morning, and that the petals fall off on the second day of anthesis.

875. **P. grandiflora** L. (Herm. Müller, 'Alpenblumen,' 219–20.)—The flowers of this species are even larger than those of P. aurea; they are also borne on longer stalks, which make them still more conspicuous. The number of insect visitors is therefore greater. The flowers are protandrous, so that at first crossing is favoured, and automatic self-pollination is rarer.

Visitors.—Herm. Müller observed 10 Muscids, 4 Syrphids, 4 beetles, 12 bees, and 13 Lepidopterids.

876. **P. verna** L.—According to Hermann Müller ('Fertilisation,' pp. 231–2), the flowers agree as regards mechanism with those of P. Anserina; but their size is less. They are of a brilliant yellow colour, and rich in nectar. Schulz describes them as slightly protogynous. The inner anthers are situated above the stigmas, so that automatic self-pollination regularly takes place.

Visitors.—Schulz observed numerous flies, beetles, and small bees in Central Germany; and Lindman noticed flies, a beetle, and a butterfly on the Dovrefjeld.

In the Alps Herm. Müller ('Alpenblumen,' p. 221) saw 17 Hymenopterids, 2 Dipterids, a beetle, and 2 Lepidopterids visiting this species, and with P. alpestris *Hall. f.*, the large-flowered form of P. salisburgensis (cf. p. 370).

I noticed a bee (Andrena albicans *Müll.* ♀), and a hover-fly (Eristalis tenax *L.*), both skg., in Schleswig-Holstein ('Bloemenbiol. Bijdragen'). Herm. Müller gives the following list for Westphalia and Thuringia.—

A. Coleoptera. (*a*) *Curculionidae*: 1. Spermophagus cardui *Stev.* (*b*) *Nitidulidae*: 2. Meligethes freq., nect-lkg. **B. Diptera.** (*a*) *Muscidae*: 3. Onesia cognata *Mg.*, skg.; 4. O. floralis *R. D.*, do.; 5. Pollenia vespillo *F.*, do. (*b*) *Stratiomyidae*: 6. Odontomyia argentata *F.*, skg. (*c*) *Syrphidae*: 7. Cheilosia modesta *Egg.*, skg.; 8. C. praecox *Zett.*, freq., skg.; 9. Rhingia rostrata *L.*, skg.; 10. Syritta pipiens *L.*, do.; 11. Syrphus sp., do. **C. Hymenoptera.** (*a*) *Apidae*: 12. Andrena albicans *Müll.*, ♀ and ♂, freq., po-cltg. and skg.; 13. A. albicrus *K.* ♂, skg.; 14. A. argentata *Sm.* ♂, do.; 15. A. dorsata *K.* ♀, po-cltg.; 16. A. fulvicrus *K.* ♂, skg.; 17. A. parvula *K.* ♀, do.; 18. A. nana *K.* ♂, do.; 19. A. xanthura *K.* ♀, do.; 20. Apis mellifica *L.* ☿, po-cltg. and skg.; 21. Bombus terrester *L.* ♀, po-cltg.; 22. Halictus albipes *F.* ♀, skg.; 23. H. cylindricus *F.* ♀, po-cltg.; 24. H. flavipes *F.* ♀, skg.; 25. H. leucopus *K.* ♀, skg. and po-cltg.; 26. H. maculatus *Sm.* ♀, po-cltg.; 27. H. morio *F.* ♀, skg.; 28. H. nitidiusculus *K.* ♀, do.; 29. H. semipunctulatus *Schenck* ♀, do.; 30. H. sexstrigatus *Schenck* ♀, po-cltg.; 31. Nomada ruficornis *L.* ♂; 32. Osmia fusca *Chr.* ♀, skg. and po-cltg. (*b*) *Formicidae*: 33. Formica pratensis *Deg.* ☿, nect-lkg.

Bees were also observed as follows by the authorities and in the places stated.—

Alfken (Bremen)—1. Andrena albicans *Müll.* ♀, occasional, skg. and po-cltg.; 2. A. albicrus *K.* ♀, freq., skg. and po-cltg.; 3. Nomada bifida *Ths.* ♀, do. Schmiedeknecht (Thuringia)—1. Andrena cyanescens *Nyl.*; 2. A. parvula *K.* Schenck (Nassau)—Andrena cingulata *F.* Friese (Hungary), Andrena genevensis, *Schmiedekn.*; (Innsbruck)—Osmia bicolor *Schr.* ♀, only po-cltg. von Dalla Torre (Tyrol)—1. Andrena parvula *K.* ♀; 2. Halictus nanulus *Schenck* ♂; 3. Osmia aurulenta *Pz.* ♂ and ♀; 4. Prosopis borealis *Nyl.* ♀. Schletterer (Tyrol)—1. Halictus albipes *F.*; 2. Prosopis communis *Nyl.*

877. **P. cinerea** Chaix (=P. arenaria *Borck.*), and

878. **P. opaca** L.—Schulz ('Beiträge,' II, pp. 67–8) states that these two species agree with P. verna as regards flower mechanism, and are visited by numerous insects, especially flies, beetles, and the smaller or more rarely the larger bees. Most of the visitors collect or devour pollen.

VISITORS.—Loew (Brandenburg) gives the following list for P. cinerea ('Beiträge,' p. 38).—

A. Diptera. *Syrphidae*: 1. Cheilosia praecox *Zett.*, po-dvg. **B. Hymenoptera.** *Apidae*: 2. Halictus morio *F.* ♀, po-cltg.; 3. H. tumulorum *L.* ♀, do.; 4. Osmia bicolor *Schr.* ♂, skg.

Schletterer observed the following bees at Pola.—

1. Andrena parvula *K.*; 2. Halictus calceatus *Scop.*; 3. H. interruptus *Pz.*; 4. H. levigatus *K.* ♀; 5. H. malachurus *K.*; 6. H. morio *F.*; 7. H. quadrinotatus *K.*; 8. Osmia versicolor *Ltr.*

879. **P. caulescens** L.—The flowers of this species are homogamous, or (according to Kerner) slightly protogynous. Visitors may effect either cross- or self-pollination, and the latter can also take place automatically (Schulz).

VISITORS.—Herm. Müller observed Apis, a Bombus, and a Melithreptus ('Alpenblumen,' p. 222).

880. **P. atrosanguinea** Lodd.—Delpino ('Ult. Oss.,' p. 233) describes the flowers of this species as protogynous, with stigmas that are only receptive for a short time. At first the stamens are curved away from the middle of the flower and their anthers are unripe, while the mature stigmas occupy the centre. The stamens subsequently raise themselves to the level of the stigmas.

VISITORS.—Delpino observed small bees (sp. of Andrena and Halictus).

881. **P. fruticosa** L. (Herm. Müller, 'Fertilisation,' p. 233; Knuth, 'Bloemenbiol. Bijdragen.')—In this species, according to Hermann Müller, nectar is so scantily secreted that it does not accumulate into little drops; but the smooth glistening ring of the receptacle surrounding the roots of the filaments is so frequently licked by insects, even by the honey-bee, that it is doubtless covered by a thin layer of it.

The flowers are homogamous. When insects alight they sometimes first touch the stigmas, sometimes the laterally dehiscing anthers. The chances of cross- and self-pollination are therefore about equal. Failing insect-visits, automatic self-pollination sometimes takes place, the withering stamens partly bending inwards, and thus bringing their anthers (to which pollen still clings) into contact with the stigmas. The number of insect visitors, however, is so large that this kind of pollination is scarcely likely to occur.

VISITORS.—Herm. Müller (H. M.), and myself (Kn.) observed the following.—

A. Coleoptera. (*a*) *Malacodermata*: 1. Dasytes flavipes *F.*, nect-lkg. and dvg. the anthers (H. M.). (*b*) *Nitidulidae*: 2. Meligethes, very freq., po-dvg. (H. M.). **B. Diptera.** (*a*) *Conopidae*: 3. Sicus ferrugineus *L.*, nect-lkg. (H. M.). (*b*) *Culicidae*: 4. Culex pipiens *L.*, skg. (H. M.). (*c*) *Muscidae*: 5. Anthomyia, very freq., nect-lkg. (H. M.); 6. Lucilia cornicina *F.*, freq., nect-lkg. (H. M.); 7. L. sylvarum *Mg.*, do. (H. M.); 8. Sarcophaga carnaria *L.*, freq., nect-lkg. (H. M.); 9. Scatophaga merdaria *F.*, do. (H. M.); 10. Sepsis, very freq., nect-lkg. (H. M.); 11. Smaller Muscids, nect-lkg. (Kn.). (*d*) *Stratiomyidae*: 12. Sargus cuprarius *L.*, freq., nect-lkg. and po-dvg. (H. M.). (*e*) *Syrphidae*: 13. Eristalis arbustorum *L.*, freq., nect-lkg. and po-dvg. (H. M.); 14. E. nemorum *L.*, skg. or po-dvg. (Kn.); 15. E. sepulcralis *L.*, do. (H. M.); 16. Helophilus floreus *L.*, as 13. (H. M.); 17. H. pendulus *L.*, do. (H. M.); 18. Melithreptus taeniatus *Mg.*, do. (H. M.); 19. Syritta pipiens *L.*, do. (H. M.); 20. Syrphus pyrastri *L.*, skg. or po-dvg. (Kn.); 21. Volucella bombylans *L.*, do. (Kn.); 22. V. pellucens *L.*, do. (H. M.). (*f*) *Tabanidae*: 23. Chrysops caecutiens *L.* ♂, nect-lkg. or po-dvg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 24. Apis mellifica *L.* ☿, freq., nect-lkg. (H. M., Kn.); 25. Halictus zonulus *Sm.* ♀, nect-lkg. (H. M.). (*b*) *Sphegidae*: 26. Oxybelus bellus *Dahlb.*, very freq., nect-lkg. (H. M.); 27. O. uniglumis *L.*, occasional, nect-lkg. (H. M.).

882. P. alchemilloides Lapeyr.—MacLeod ('Pyreneenbl.,' pp. 25–9) has fully described the mechanism of this Pyrenean species. The diameter of the white flowers is 20 mm. Between the carpels and the bases of the stamens there is a nectar-groove bounded by two hairy ridges, and most conveniently accessible at five spots. The flowers are almost homogamous: probably the anthers dehisce a little before the stigmas are mature. Insect visitors may effect either cross- or self-pollination. The latter can only take place automatically with difficulty, for the anthers are turned away from the stigmas; but now and then it is brought about by a stamen remaining erect.

VISITORS.—MacLeod observed 2 Empids and 5 Muscids in the Pyrenees.

883. P. sterilis Garcke (=Fragaria sterilis *L.*, P. Fragariastrum *Ehrh.*, and P. Fragaria *Poir.*). (MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 429–30, vi, 1894, pp. 314–15.)—MacLeod examined the mechanism of the white flowers of this species in the Pyrenees and in Belgium. In the former region the diameter of the flower is 20 mm.; in the latter only 11–12 mm. Between the stamens and the carpels there is a pentagonal hairy orange-coloured (Belgium) or reddish-brown (Pyrenees) nectar-ring. In late anthesis the stamens bend inwards so much that automatic self-pollination results from the contact between anthers and stigmas. In Belgium the flowers are slightly protogynous.

VISITORS.—MacLeod observed small beetles and flies, and an Acarid in Flanders; and a bee, a Muscid, and a Lepidopterid in the Pyrenees.

Burkill ('Fertlsn. of Spring Fls.') noticed the following on the Yorkshire coast.—

A. Coleoptera. *Curculionidae*: 1. Apion nigritarse *K.*, skg. **B. Diptera.** (*a*) *Muscidae*: 2. Coelopa sp., po-dvg.; 3. Lucilia cornicina *F.*, skg.; 4. Onesia cognata *Mg.*, do.; 5. Sepsis nigripes *Mg.*, skg.; 6. Siphona geniculata *Deg.*, skg.; 7. one other Muscid. (*b*) *Phoridae*: 8. Phora sp. **C. Hymenoptera.** (*a*) *Apidae*: 9. Andrena clarkella *K.* ♂ and ♀; 10. A. gwynana *K.* ♂, skg., ♀ po-cltg. (*b*) *Formicidae*: 11. Formica fusca *L.*, skg. (*c*) *Ichneumonidae*: 12. three small sp.

884. P. Sommerfeltii Lehm., **885. P. Ranunculus** Lange, **886. P. Vahliana** Lehm., **887. P. Frieseana** Lange, and **888. P. tridentata** Ait.—These and

other Arctic species (Nos. **860, 872,** and **889–891**) rapidly set fruits, and are otherwise well adapted to the conditions of life obtaining in high latitudes. Warming describes them as probably homogamous, and relying upon automatic self-pollination (cf. Loew, '*Blütenbiol. Floristik*,' p. 99).

889. P. fragiformis Willd., var. **parviflora** Trautw. (the species = P. emarginata *Pursh*, according to Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 8).—In Spitzbergen this species is one of the earliest spring plants, and was observed in flower 21.6.'96, 30.6.'82, 1.7.'98, and 7.7.'61. The last two dates apply to North-east Land in 80° N. lat. Andersson and Hesselman state that abundant fruits are set ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 19–20).

The specimens which Vanhöffen collected in Greenland and described as the variety (*a*) *typica* (= P. emarginata *Pursh*) bear flowers 15–17 mm. in diameter, with dark yellow petals traversed by darker veins. In the variety (*c*) *elatior* (= P. fragiformis *Willd.*) the flowers are larger, their diameter being not infrequently 20 mm.: petals pale yellow, but darker and distinctly veined at their bases. The development of the petals is clearly dependent upon oecological conditions.

Ekstam says that this species and its variety *parviflora* are also native to Nova Zemlia (Bot. Jahrb., Leipzig, xxii, 1897, p. 195).

890. P. pulchella R. Br.—This species was found flowering in Spitzbergen from June to the beginning of September, chiefly, however, in the second half of July. Fruits are set and ripened in a normal way (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 19). Several varieties of this species occur in Greenland (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 7–8).

891. P. nivea L.—This species was found flowering in Spitzbergen on 12.7.'90, and ripe fruits were collected on 6.8.'82 (Andersson and Hesselman, op. cit., p. 20). It is very polymorphous in Greenland. Here the yellow petals project but little beyond the calyx: numerous fruits were noticed (Abromeit, op. cit., pp. 9–11).

Visitors.—Lindman noticed a medium-sized fly on the Dovrefjeld.

892. P. rupestris L.—This species, which was studied at Bozen by Schulz ('Beiträge,' p. 68), is capable of automatic self-pollination, for the inner anthers incline somewhat towards the middle of the flower, so as to be above the simultaneously mature stigmas upon which pollen can therefore fall. As but little nectar is secreted, and the white flowers are not conspicuous, the number of insect-visits is small.

Visitors.—Schulz observed flies, beetles, and bees. MacLeod saw 5 Syrphids and 5 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 431). Loew noticed Apis, skg., in the Berlin Botanic Garden.

893. P. alba L.—The flower mechanism of this species agrees, according to Kirchner ('Flora v. Stuttgart,' p. 447), with those of P. verna, P. opaca, and P. Anserina.

894. P. micrantha Ram.—In the flowers of this species, according to Kerner, the stamens form a hollow cone which covers the nectar-secreting receptacle.

895. P. hirta Vill.—

VISITORS.—Schletterer observed the following **Hymenoptera** at Pola.—

(*a*) *Apidae*: 1. Andrena lucens *Imh.*; 2. A. thoracica *F.*; 3. Halictus fasciatellus *Schenck*; 4. H. villosulus *K.*; 5. Prosopis clypearis *Schenck.* (*b*) *Tenthredinidae*: 6. Amasis laeta *F.*

896. P. delphinensis Gren. et Godr., and **897. P. Kurdica** Boiss. et Hohen.—

VISITORS.—Loew saw Apis, skg. and po-cltg., in the Berlin Botanic Garden.

898. P. chrysantha Trevir.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. Syritta pipiens *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.

899. P. Meyeri Boiss., var. **Fenzlii** Lehm.—

VISITORS.—Loew saw the bee Prosopis communis *Nyl.* ♀, po-dvg., in the Berlin Botanic Garden.

252. Sibbaldia L.

Homogamous greenish-yellow flowers, with exposed nectar secreted in the usual place.

900. S. procumbens L. (Herm. Müller, 'Alpenblumen,' p. 222.)—In this species the exposed nectar is secreted by the broad fleshy disk which surrounds the ten carpels. It is eagerly visited by short-tongued insects (Muscids, ants, Ichneumonids), and these effect cross- and self-pollination. The possibility of automatic self-pollination seems to be excluded, for though the anthers mature simultaneously with the stigmas, they are so far from them that transfer of pollen cannot take place autogamously. Lindman, however, says that self-pollination is a much easier matter in plants of the species growing in the Scandinavian Highlands. Warming makes the same statement for Greenland.

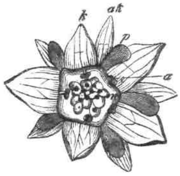


FIG. 116. *Sibbaldia procumbens, L.* (after Herm. Müller). Flower seen directly from above (× 7). *a*, anther; *ak*, epicalyx; *k*, sepal; *n*, nectary; *p*, petal.

253. Alchemilla L.

Small, greenish apetalous flowers; with exposed nectar secreted by a fleshy ring on the inner wall of the receptacle.

901. A. vulgaris L. (Herm. Müller, 'Fertilisation,' pp. 234–5; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Schulz, 'Beiträge,' II, p. 188; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Loew, 'Blütenbiol. Floristik,' p. 396.)—Schulz states that this species is very commonly gynomonoecious and gynodioecious, as well as andromonoecious and androdioecious; and that in some districts hermaphrodite flowers are entirely absent. According to Hermann Müller, the fleshy yellow ring on the inner side of the receptacle, which surrounds the style at the time of

flowering, secretes a thin layer of nectar that gives a yellowish appearance to the whole inflorescence. The stamens and pistil are rarely developed normally: either the stamens are developed, while the style remains so short that the stigma hardly projects beyond the nectary, or the style is long, and 1–3 or all four of the stamens are reduced. Automatic self-pollination is therefore rendered very difficult. Kerner, however, says that it may take place in the hermaphrodite flowers, which are protogynous and therefore primarily adapted for cross-pollination, for the stigma remains receptive till the anthers are ripe, and is brought into contact with them by elongation of the style.

VISITORS.—Herm. Müller saw a hover-fly (Xanthogramma citrofasciata *Deg.*), and Lindman noticed flies on the Dovrefjeld.

Herm. Müller observed 3 Lepidoptera and 6 flies in the Alps ('Alpenblumen,' pp. 223–4); Loew saw the hover-fly Melithreptus scriptus *L.* in Switzerland ('Beiträge,' p. 55); and MacLeod noticed a beetle and 5 flies in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 433).

Plateau observed flies (Calliphora, Musca, Scatophaga, and Syritta pipiens *L.*) and small Hymenoptera in Belgium.

FIG. 117. ***Alchemilla vulgaris***, *L.* (after Herm. Müller). (1) Flower with normal stamens and a short style, seen directly from above. (2) The same, seen obliquely from above. (3) Flower with one normal and three vestigial stamens, and normal style; seen obliquely from above. (4) Flower with all the stamens vestigial, and well-developed style. *a*, epicalyx; *b*, calyx; *c*, stamens; *c*', vestigial stamens; *d*, stigma; *e*, nectary.

In Dumfriesshire, a long-tongued bee, a Tenthredinid, 2 Empids, several other flies, and 2 Lepidoptera were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 59).

In spite of repeated watching, I have never observed any insects on the flowers.

902. A. alpina L., **903. A. fissa** Schum., and **904. A. pentaphyllea L.**—Hermann Müller ('Alpenblumen,' pp. 222–3) states that these species agree with A. vulgaris and Sibbaldia procumbens, as regards their flower mechanism, the distribution of sexes, and the degeneration of various organs. Trimerous and pentamerous flowers are not infrequent. (Cf. Fig. 118.)

VISITORS.—Herm. Müller saw small Muscids, beetles, ants, and Ichneumonids.

MacLeod observed (on A. alpina) 2 beetles and 4 flies in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 433). Loew noticed a small bee (Sphecodes gibbus *L.* ♀), skg., in the Berlin Botanic Garden.

905. A. arvensis Scop.—The very insignificant green flowers of this species are associated in small dense sessile glomerate cymes, but in spite of this are extremely inconspicuous. Kirchner ('Flora v. Stuttgart,' p. 449) says there is a nectary, but it is green and non-functional. The single stamen slants obliquely inwards, so that its anther is situated above the stigma, and automatic self-pollination is inevitable.

906. A. acutiloba Stev.—

Visitors.—Loew observed a Bombyliid (Anthrax morio *L.*, skg.) and a Syrphid (Eristalis tenax *L.*, do.) in the Berlin Botanic Garden.

254. Sanguisorba L.

Flowers apetalous, associated in capitula; either with half-concealed nectar, or anemophilous.

907. S. officinalis L. (Herm. Müller, 'Fertilisation,' p. 236, 'Alpenblumen,' pp. 224–5.)—In the homogamous flowers of this species the receptacle encloses the ovary, and possesses a nectar-secreting ring that surrounds the base of the style. There are four ovate sepals, concave at their bases, and coloured red above. They serve as nectar receptacles, and also as a means of making the flower more conspicuous. The 50–100 florets of a capitulum open in succession from below upwards in such a way that only a zone one floret deep is in bloom at the same time. In favourable weather insects appear in considerable numbers, and usually effect

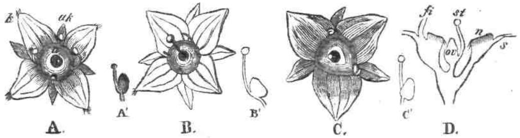


Fig. 118. *Alchemilla fissa, Schum.* (after Herm. Müller). *A.* Hermaphrodite tetramerous flower. *A*[1]. Pistil of same. *B.* Female tetramerous flower. *B*[1]. Pistil of same. *C.* Hermaphrodite trimerous flower, with one vestigial stamen. *C*[1]. Pistil of same. *D.* Flower in section. *ak*, epicalyx; *k*, calyx; *fi*, filament; *s*, sepal; *st*, stigma; *ov*, ovary; *n*, nectary.

crossing, for as a rule they touch the stigma and anthers with different sides of their heads. Sometimes, however, they bring about self-pollination, which may easily take place automatically.

Visitors.—Herm. Müller observed 4 Muscids, a Syrphid, and 11 Lepidoptera in the Alps. Loew noticed one species of hover-fly (Didea alneti *Fall.*) in the same region, and another (Syritta pipiens *L.*) in the Berlin Botanic Garden. Rössler saw a butterfly (Lycaena euphemus *Hb.*) at Wiesbaden.

In Dumfriesshire 5 Muscids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 60).

Kerner gives the butterfly Lycaena arcas *Rott.*, for the caterpillars of which this species is the food-plant.

908. S. minor Scop. (=Poterium Sanguisorba *L.*). (Herm. Müller, 'Fertilisation,' p. 236; Axell, 'Om Anord. för Fanerog. Växt. Befrukt., p. 54.)—This species is nectarless, anemophilous, and, according to Kirchner ('Flora v. Stuttgart,' pp. 456–7), coenomonoecious. The male flowers are at the bases of the capitula, the hermaphrodite ones in the middle, and the female ones at the top. Schulz 'Beiträge,' II, pp. 69–70, 188) observed gynomonoecism, andromonoecism, and even pure monoecism. The hermaphrodite flowers are usually homogamous, and the distribution of the sexes varies very much in individual plants. At Ruppin, according

to Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896), only the uppermost flowers of the capitula are female, as a rule, and are in a minority; the other flowers are male, often with an isolated hermaphrodite flower here and there between them. The anthers are yellow, and pendulous on long reddish filaments. The hermaphrodite flowers possess but few stamens. The pollen-grains are of a dirty yellowish-white colour, rounded-polyhedral, smooth, up to 37 μ in diameter. Ludwig says that not infrequently there are variations in the colour of the stamens of different male flowers, from which the anthers hang down limply on long thin filaments. As a rule the anthers are yellow, and the filaments white; but stocks also occur in which the filaments are red, and the anthers yellowish-red to red. In the female flowers the style and the large spreading stigma are red to wax-yellow or white.

VISITORS.—Herm. Müller ('Fertilisation,' p. 236) saw a wasp (Odynerus parietum *L.* ♀) settle on the flowers, flying away again after a short and profitless search. I noticed a hover-fly (Melanostoma mellina *L.*), po-dvg., on the inflorescence.

In Dumfriesshire a Tenthredinid and 2 hover-flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 61).

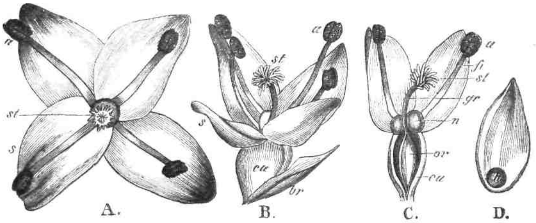


FIG. 119. *Sanguisorba officinalis, L.* (after Herm. Müller). *A.* Flower seen directly from above. *B.* The same, seen from the side. *C.* The same, in longitudinal section. *D.* Single sepal, seen from within. (× 7) *a*, anther; *br*, bract; *ca*, receptacle; *fi*, filament; *gr*, style; *h*, drop of nectar; *n*, nectary; *ov*, ovary; *s*, sepal; *st*, stigma.

909. S. alpina Bunge.—In this species, as in Thalictrum aquilegiifolium, the filaments are claviform, and therefore shaken by the slightest breath of air, so that the pollen is scattered (Kerner, 'Nat. Hist. Pl.,' II, p. 145).

255. Poterium L.

910. P. spinosum L.—Pirotta states that this species is anemophilous (Annuario R. Inst. Bot. Roma, iii, 1887). Hermaphrodite flowers are only to be found on cultivated plants: wild ones (in Sardinia) bear only unisexual flowers, and purely female inflorescences are commoner than such as bear both kinds of flowers, while the number of male flowers in the latter is seldom larger than that of the female ones. Cultivated plants more frequently bear polygamous inflorescences than purely female ones.

911. P. polygama Waldst. et Kit.—Kerner describes this species as trimonoecious. The number of stamens in the hermaphrodite flowers is sometimes reduced from 8 to 1.

256. Agrimonia Tourn.

Yellow, homogamous, pollen flowers with pseudo-nectaries.

912. A. Eupatoria L. (Herm. Müller, 'Fertilisation,' pp. 235–6; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 319–20; Kirchner, 'Flora v. Stuttgart,' p. 457; Knuth, 'Bloemenbiol. Bijdragen.')—At the base of the two styles in this species there is a fleshy ring, that looks like a nectary, though no secretion has been observed. The 5–7 stamens on the margin of this disk attain the same level as the stigmas, and their anthers dehisce laterally. The anthers incline inwards, and therefore come into contact with the stigmas. The individual flowers bloom for a single day only, and open very early in the morning. The stamens, which are at first divergent, bend inwards in the course of the day, until they touch one another and the stigmas. Comparatively few insects visit the flowers, but these may bring about either cross- or self-pollination. From the above description it is clear that the latter occurs automatically, and it is obviously effective.

VISITORS.—Herm. Müller (H. M.) and myself (Kn.) observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., po-dvg. (H. M.). (*b*) *Syrphidae*: 2. Ascia podagrica *F.*, po-dvg. (H. M.); 3. Eristalis nemorum *L.*, do. (Kn.); 4. E. tenax *L.*, do. (H. M.); 5. Melanostoma mellina *L.*, do. (H. M.); 6. Melithreptus dispar *Loew*, do. (H. M.); 7. M. pictus *Mg.*, do. (H. M.); 8. M. scriptus *L.*, do. (H. M.); 9. M. taeniatus *Mg.*, do. (H. M.); 10. Rhingia rostrata *L.*, do. (H. M.); 11. Syritta pipiens *L.*, do. (H. M.); 12. Syrphus ribesii *L.*, do. (Kn.). **B. Hymenoptera.** *Apidae*: 13. Apis mellifica *L.* ☿, po-cltg. (Kn.); 14. Bombus terrester *L.* ♀ and ☿, do. (Kn.); 15. Halictus, small sp. ♀, do. (H. M.).

Schletterer records Bombus pascuorum *Scop.* for the Tyrol.

913. A. odorata Mill.—

VISITORS.—Alfken noticed bees (Apis and Prosopis sp.) at Bremen.

257. Ulmaria Hill.

White, hermaphrodite, homogamous pollen flowers, devoid of nectar.

914. U. pentapetala Gilib. (= Filipendula Ulmaria *Maxim.*, and Spiraea Ulmaria *L.*). (Herm. Müller, 'Fertilisation,' pp. 222–3, 'Weit. Beob.,' II, p. 243; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Schulz, 'Beiträge,' II, p. 186; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234, 'Bloemenbiol. Bijdragen.)—

The flowers of this species are yellowish-white in colour, and associated in dense crowded inflorescences. Their conspicuous appearance, and the strong odour of almonds they exhale, attract numerous insect visitors, to which a large quantity of pollen is afforded. According to Hermann Müller's account the stamens at first incline together in the middle of the flower, so as completely to cover the stigmas. They then gradually erect themselves in centripetal order, and bend somewhat outwards. Meanwhile the anthers dehisce, and get covered with pollen all round. When the innermost stamens have become erect, the centre of the flower occupied by the stigmas is the most convenient alighting-place for insects. These can therefore easily effect crossing, though they are just as likely to bring about self-pollination. Failing insect visitors automatic self-pollination takes place. Owing to

the crowded nature of the inflorescences automatic cross-pollination may also happen by the fall of pollen upon the stigmas of neighbouring flowers. Schulz observed andromonoecious stocks.—

VISITORS.—I observed the following, all po-dvg.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Gaurotes virginea *L.*; 2. Judolia cerambyciformis *Schr.*; 3. Leptura livida *F.*; 4. L. maculicornis *Deg.*; 5. Stenocorus mordax *Deg.* (*b*) *Chrysomelidae*: 6. Cryptocephalus sericeus *L.* (*c*) *Scarabaeidae*: 7. Trichius fasciatus *L.* **B. Diptera.** *Syrphidae*: 8. Syritta pipiens *L.*, freq.

Herm. Müller gives the following list.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Judolia cerambyciformis *Schr.*; 2. Leptura maculicornis *Deg.*, dvg. the flowers; 3. Pachyta quadrimaculata *L.*, dvg. the anthers; 4. Strangalia attenuata *L.*, do.; 5. S. quadrifasciata *L.*, dvg. the flowers. (*b*) *Cleridae*: 6. Trichodes apiarius *L.*, dvg. the flowers. (*c*) *Dermestidae*: 7. Anthrenus pimpinellae *F.*, dvg. the flowers. (*d*) *Mordellidae*: 8. Mordella aculeata *L.* (*e*) *Nitidulidae*: 9. Cychramus luteus *Oliv.* (*f*) *Scarabaeidae*: 10. Cetonia aurata *L.*, dvg. the flowers; 11. Trichius fasciatus *L.*, do. (*g*) *Telephoridae*: 12. Malachius bi-

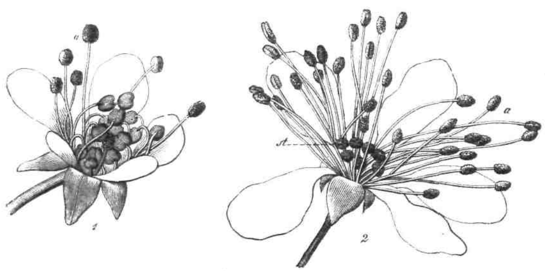


FIG. 120. *Ulmaria pentapetala, Gilib.* (after Herm. Müller). (1) Young flower. (2) Older flower. (*a*) anthers; *st*, stigmas.

pustulatus *L.*, dvg. the anthers. **B. Diptera.** (*a*) *Muscidae*: 13. Anthomyia sp. (*b*) *Syrphidae* (all po-dvg.): 14. Eristalis arbustorum *L.*, very freq.; 15. E. horticola *Deg.*; 16. E. nemorum *L.*; 17. E. sepulcralis *L.*; 18. E. tenax *L.*; 19. Helophilus floreus; 20. Syritta pipiens *L.*; 21. Volucella bombylans *L.*; 22. V. pellucens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 23. Andrena coitina *K.* ♀, po-cltg.; 24. Apis mellifica *L.* ☿, freq., po-cltg.; 25. Prosopis armillata *Nyl.* ♂, freq., po-dvg.; 26. P. clypearis *Schenck* ♂, po-dvg.; 27. P. communis *Nyl.* ♂, do.; 28. P. confusa *Nyl.* ♂, do.; 29. Xylocopa violacea *L.* ♀, po-cltg. (*b*) *Chrysididae*: 30. Chrysis ignita *L.*; 31. Ellampus auratus *L.*; 32. Hedrychum nobile *Scop.* (*c*) *Sphegidae*: 33. Pemphredon unicolor *F.*; 34. Crabro larvatus *Wesm.* ♀; 35. C. wesmaeli *v. d. L.* ♂. **D. Lepidoptera.** 36. Zygaena pilosellae *Esp.*, trying to suck.

Von Fricken records 2 Cerambycids (Clytus figuratus *Scop.* and Grammoptera ruficornis *F.*) and a Curculionid (Apoderus erythropterus *Zschoch.* = A. intermedius *Ill.*) for Westphalia and East Prussia. Redtenbacher gives 2 Cerambycids (Molorchus minimus *Scop.* and Obrium brunneum *F.*) for Austria.

Alfken saw the humble-bee Bombus terrester *L.* ☿ at Bremen, and Loew observed the following in Silesia ('Beiträge,' p. 28).—

A. Coleoptera. (*a*) *Mordellidae*: 1. Anaspis frontalis *L.* (*b*) *Nitidulidae*: 2. Meligethes sp. (*c*) *Scarabaeidae*: 3. Cetonia aurata *L.*, dvg. the anthers. **B. Diptera.** (*a*) *Muscidae*: 4. Anthomyia sp. (*b*) *Syrphidae*: 5. Chrysogaster coemeteriorum *L.*, po-dvg. **C. Lepidoptera.** *Rhopalocera*: 6. Argynnis pandora *S. V.*, vainly searching for nectar.

Willis noticed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Epuraea melina *Er.*, po-dvg.; 2. Meligethes aeneus *F.*, freq., po-dvg.; 3. M. viridescens *F.*, do. **B. Diptera.** (*a*) *Muscidae*: 4. Anthomyia radicum *L.*, freq., po-dvg.; 5. Mydaea sp., po-dvg.; 6. Trichophthicus hirsutulus *Zett.*, do. (*b*) *Syrphidae* (all po-dvg.): 7. Eristalis aeneus *Scop.*; 8. E. horticola *Deg.*; 9. E. tenax *L.*; 10. Melanostoma mellina *L.* (*c*) *Chironomidae*: 11. Corynoneura sp., po-dvg.

Herm. Müller saw the beetle Cetonia aurata *L.*, freq., in the Alps ('Alpenblumen,' p. 228). MacLeod observed (Pyrenees) a short-tongued bee and 2 beetles (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 426–7): also (Flanders) Apis, a humble-bee, 12 hover-flies, a saw-fly, 3 beetles, and a Lepidopterid (op. cit., vi, 1894, pp. 321–2, 380). Heinsius noticed 2 po-dvg. flies (Helophilus floreus *L.* ♀ and Cyrtoneura curvipes *Macq.* ♀) in Holland (op. cit., iv, 1892, p. 57). Lindman saw numerous flies on the Dovrefjeld.

915. U. Filipendula Hill (= Spiraea Filipendula *L.*, and Filipendula hexapetala *Gilib.*). (Herm. Müller, 'Fertilisation,' pp. 223–4.)—The faintly fragrant inflorescences of this species attract far fewer insects than the much larger ones of U. pentapetala. Hermann Müller ('Beiträge,' II, p. 12) describes the white petals as possessing such slender claws that they are very easily bent down, and cannot serve as alighting-places for insects. They are somewhat reflexed when the flower has fully opened. The stamens also bend far outwards before the anthers dehisce, so that the 9–12 broad, bilobed styles that radiate from the centre of the flower serve as the most convenient platform for insect visitors, which therefore regularly effect crossing. Should insect-visits fail, automatic self-pollination takes place; the innermost stamens often remaining bent inwards till their anthers dehisce, so that the pollen comes into contact with the stigmas. Schulz says that late-flowering stocks are sometimes andromonoecious.

Visitors.—Hermann Müller observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia bifasciata *Müll.* ♀, po-dvg. (*b*) *Oedemeridae*: 2. Oedemera podagrariae *L.*, po-dvg. (*c*) *Scarabaeidae*: 3. Cetonia aurata *L.*, gnawing the anthers; 4. Trichius fasciatus *L.*, rapidly gnawing the anthers from below upwards. **B. Diptera.** *Syrphidae* (all po-dvg.): 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. Helophilus floreus *L.*; 8. Syritta pipiens *L.* **C. Hymenoptera.** *Apidae*: 9. Halictus sexnotatus *K.* ♀, po-cltg.; 10. H. zonulus *Sm.* ♀, do.

Loew saw a Syrphid (Eristalis tenax *L.*, po-dvg.) and a bee (Apis mellifica *L.* ☿, po-cltg.) in the Berlin Botanic Garden.

258. Spiraea L.

White or red hermaphrodite flowers, often protogynous; mostly smelling like hawthorn; with half-concealed nectar secreted in abundance by an annular orange-yellow thickening on the inner wall of the receptacle, internal to the insertions of the

stamens. In some species, according to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 326), geitonogamy takes place. For though the direction of the style and the position of the stigma remain unchanged the filaments elongate, and curve in such a way that the pollen can reach the stigmas of neighbouring flowers.

916. **S. sorbifolia** L. (Herm. Müller, 'Fertilisation,' pp. 224–6.)—This Siberian species, cultivated in our parks and gardens as an ornamental shrub, attracts

FIG. 121. *Spiraea sorbifolia, L.* (after Herm. Müller). (1) Flower immediately after opening. (2) Older flower, with some of the stamens dehisced. *a*, dehisced anthers; *st*, stigma; *n*, nectary.

numerous insects by its large fragrant inflorescences, and because of its richness in nectar and pollen. Hermann Müller says that the flowers are distinctly protogynous, and that even in the bud the broad capitate stigmas are provided with papillae and project beyond the stamens, which are bent inwards towards one another. When the flower opens the stamens gradually become erect, and successively dehisce from without inwards. Insects therefore effect crossing at the beginning of anthesis; later

on they may also bring about self-pollination, for the stigmas remain receptive till the innermost anthers dehisce. The latter may also occur automatically.

VISITORS.—*Vide infra.*

917. S. salicifolia L., and **918. S. ulmifolia** Scop. (Herm. Müller, 'Fertilisation,' pp. 224–6, 'Weit. Beob.,' II, p. 243.)– These species are cultivated along with S. sorbifolia as ornamental shrubs.

VISITORS.—Herm. Müller gives the following list for these two species and S. sorbifolia, all three of which flower at the same time.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.*, nect-lkg.; 2. Grammoptera ruficornis *F.*, do.; 3. Leptura livida *F.*, very freq., nect-lkg.; 4. Strangalia armata *Hbst.*, nect-lkg.; 5. S. attenuata *L.*, freq., nect-lkg.; 6. S. nigra *L.*, nect-lkg. (*b*) *Cistelidae*: 7. Cistela murina *L.*, freq., dvg. the anthers and petals. (*c*) *Dermestidae*: 8. Anthrenus muscorum *L.*, very freq., nect-lkg.; 9. A. pimpinellae *F.*, do.; 10. A. scrophulariae *L.*, do.; 11. Attagenus pellio *L.*, do.; 12. Byturus fumatus *F.*, do. (*d*) *Elateridae*: 13. Cardiophorus cinereus *Hbst.*, nect-lkg.; 14. Lacon murinus, *L.*, do. (*e*) *Lagriidae*: 15. Lagria hirta *L.*, nect-lkg. (*f*) *Mordellidae*: 16. Anaspis frontalis *L.*, freq., nect-lkg.; 17. A. maculata *Fourc.*, nect-lkg. (*g*) *Nitidulidae*: 18. Meligethes, freq. (*h*) *Scarabaeidae*: 19. Cetonia aurata *L.*; 20. Phyllopertha horticola *L.*, dvg. the flowers; 21. Trichius fasciatus *L.*, do. (*i*) *Telephoridae*: 22. Cantharis fulva *Scop.*; 23. Dasytes flavipes *F.*; 24. Malachius bipustulatus *L.*, dvg. the anthers. **B. Diptera.** (*a*) *Bibionidae*: 25. Bibio hortulanus *L.*, nect-lkg. (*b*) *Chironomidae*: 26. Ceratopogon sp., in large numbers, skg. (*c*) *Conopidae*: 27. Myopa polystigma *Rond.*, skg.; 28. Physocephala rufipes *F.*, do. (*d*) *Empidae*: 29. Empis opaca *F.*, freq., skg.; 30. E. punctata *F.*, skg.; 31. E. tesselata *F.*, very freq., skg. (*e*) *Muscidae*: 32. Sp. of Anthomyia; 33. Cyrtoneura simplex *Loew*; 34. Echinomyia fera *L.*; 35. E. magnicornis *Zett.* (Borgstette); 36. Gymnosoma rotundata *L.*; 37. Lucilia cornicina *F.*, skg.; 38. L. sylvarum *Mg.*, do.; 39. Mesembrina meridiana *L.*; 40. Musca corvina *F.*; 41. Onesia cognata *Mg.*; 42. O. floralis *R.-D.*; 43. Sarcophaga carnaria *L.*, skg. (*f*) *Stratiomyidae*: 44. Odontomyia viridula *F.*, skg.; 45. Stratiomys riparia *Mg.*, do. (*g*) *Syrphidae*: 46. Ascia lanceolata *Mg.*, skg.; 47. A. podagrica *F.*, do.; 48. Cheilosia gilvipes *Zett.*, skg. and po-dvg.; 49. Chrysogaster viduata *L.*; 50. Chrysotoxum festivum *L.*; 51. Eristalis arbustorum *L.*, freq., skg. and po-dvg.; 52. E. intricarius *L.*, do.; 53. E. nemorum *L.*, do.; 54. E. pertinax *Scop.*, do.; 55. E. sepulcralis *L.*, do.; 56. E. tenax *L.*, do.; 57. Helophilus floreus *L.*, freq., skg.; 58. Melithreptus strigatus *Staeg.*; 59. Pipiza funebris *Mg.*; 60. Rhingia rostrata *L.*, in great numbers, skg.; 61. Syritta pipiens *L.*, do.; 62. Syrphus excisus *Zett.*; 63. S. ribesii *L.*, po-dvg.; 64. Volucella bombylans *L.*, var. plumata *Mg.*; 65. Xylota ignava *Pz.*; 66. X. lenta *Mg.*; 67. X. segnis *L.* (*h*) *Tabanidae*: 68. Chrysops caecutiens *L.* ♂, skg. (*i*) *Tipulidae*: 69. Pachyrhina pratensis *L.*, nect-lkg. **C. Hymenoptera.** (*a*) *Apidae*: 70. Andrena albicans *Müll.* ♀, freq., skg. and po-cltg.; 71. A. albicrus *K.* ♀ and ♂, do.; 72. A. dorsata *K.* ♀, do.; 73. A. fucata *Sm.* ♀, do.; 74. A. fulvicrus *K.* ♂, skg.; 75. A. nigroaenea *K.* ♂, do.; 76. A. parvula *K.* ♀, freq., skg. and po-cltg.; 77. A. schrankella *Nyl.* ♂, skg.; 78. A. trimmerana *K.* ♀, do.; 79. Apis mellifica *L.* ☿, skg. and po-cltg.; 80. Bombus muscorum *F.* ♀, po-cltg.; 81. B. scrimshiranus *K.* ☿, running quickly over the inflorescences and po-cltg.; 82. B. terrester *L.* ♀, skg. and po-cltg.; 83. Halictus flavipes *F.* ♀; 84. H. sexnotatus *K.* ♀, po-cltg.; 85. H. sexstrigatus *Schenck* ♀, skg.; 86. H. villosulus *K.* ♀, do.; 87. Nomada ruficornis *L.* ♀, do.; 88. Osmia rufa *L.* ♀, po-cltg.; 89. Sphecodes gibbus *L.* ♀, skg. (Budd.). (*b*) *Chrysididae*: 90. Hedrychum lucidulum *F.* ♂. (*c*) *Evaniidae*: 91. Foenus sp., nect-lkg. (Budd.). (*d*) *Formicidae*: 92. Lasius niger *L.* ☿, nect-lkg.; 93. Myrmica levinodis *Nyl.* ☿; 94. Numerous small ants, nect-lkg., and preying on the minute black midges often found nect-lkg. (*e*) *Ichneumonidae*: 95. Various sp. (*f*) *Sphegidae*: 96. Ammophila sabulosa *L.*;

97. Cerceris arenaria *L.*, not infreq.; 98. Crabro lapidarius *Pz.* ♂, skg.; 99. Oxybelus bellus *Dahlb.*, very freq., skg.; 100. O. uniglumis *L.*, do.; 101. Passaloecus insignis *Shuck.* ♀, skg.; 102. Psen atratus *Pz.*, do. (*g*) *Pompilidae*: 103. Pompilus minutus *Dahlb.*, skg. (*h*) *Tenthredinidae*: 104. Allantus temulus *Scop.*, nect-lkg. (*i*) *Vespidae*: 105. Odynerus spinipes *L.* **D. Lepidoptera.** 106. Adela croessella *Scop.*, freq., skg.; 107. Dichrorampha plumbagana *Tr.* **E. Neuroptera.** 108. Agrion settled on the flowers not infrequently, apparently only to sun itself; 109. Panorpa communis *L.*, nect-lkg. **F. Orthoptera.** 110. Ectobia lapponica *L.*, nect-lkg. (?).

Loew observed the following on S. salicifolia in Silesia ('Beiträge,' p. 30).—

A. Coleoptera. (*a*) *Malacodermata*: 1. Dasytes flavipes *F.*, nect-lkg. (*b*) *Nitidulidae*: 2. Meligethes sp. **B. Hymenoptera.** *Vespidae*: 3. Odynerus sinuatus *F.* ♀, skg.

Schenck noticed the bee Andrena gwynana *K.* in Nassau.

H. de Vries records a bee (Apis mellifica *L.* ☿) and a humble-bee (Bombus terrester *L.* ♂) for the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

919. S. opulifolia L.—F. Ludwig expresses the opinion (Kosmos, Stuttgart, xvii, 1885, p. 203) that the red colour assumed by the ovary in this species after the flower has faded serves to keep away unbidden guests from blossoms that are still fresh and retain their original hue.

VISITORS.—Alfken observed 2 bees (Prosopis communis *Nyl.* ♂, and Andrena albicans *Müll.* ♀) at Bremen; and F. F. Kohl saw a wasp (Odynerus oviventris *Wesm.*) in the Tyrol.

920. S. digitata Willd.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Scarabaeidae*: 1. Cetonia aurata *L.*, freq., dvg. the flowers; 2. Phyllopertha horticola *L.*, do. **B. Diptera.** *Syrphidae*: 3. Eristalis nemorum *L.*, po-dvg. **C. Hymenoptera.** *Apidae*: 4. Apis mellifica *L.* ☿, po-cltg.

259. Aruncus L.

Yellowish-white dioecious pollen flowers, devoid of nectar, and aggregated into large inflorescences.

921. A. sylvestris Kostel. (= Spiraea Aruncus *L.*). (Herm. Müller, 'Fertilisation,' p. 224.)—The flowers of this species are polygamous-dioecious. Kerner says:—'It produces true hermaphrodite flowers and pseudo-hermaphrodite male and female flowers. The three kinds of flowers are arranged thus: (1) some plants bear only pseudo-hermaphrodite female flowers, (2) others only pseudo-hermaphrodite male flowers, (3) some bear both hermaphrodite flowers and pseudo-hermaphrodite male flowers, and (4) in addition there are yet other plants whose flowers are all hermaphrodite' ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 300).

VISITORS.—Herm. Müller (loc. cit., and 'Weit. Beob.,' II, p. 243) gives the following list.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus claviger *Er.*, occasional; 2. A. muscorum *L.*; 3. A. pimpinellae *F.*, very freq.; 4. A. scrophulariae *L.*, not infreq.; 5. Attagenus schaefferi *Hbst.* (*b*) *Nitidulidae*: 6. Meligethes freq. **B. Diptera.** (*a*) *Muscidae*: 7. Sp. of Anthomyia, po-dvg. (*b*) *Syrphidae*: 8. Syritta pipiens *L.*, very freq., po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 9. Prosopis armillata *Nyl.*;

10. P. clypearis *Schenck* ♂, freq., po-dvg.; 11. P. communis *Nyl.* ♂, do.; 12. P. signata *Pz.* ♀ and ♂, po-dvg. (*b*) *Sphegidae*: 13. Oxybelus bellus *Dahlb.*, po-dvg.; 14. O. uniglumis *L.* (*c*) *Vespidae*: 15. Odynerus sinuatus *F.*

Herm. Müller saw a Cerambycid in the Alps ('Alpenblumen,' p. 228).

Sickmann noticed the following **Hymenoptera** at Osnabrück.—

Hymenoptera. *Sphegidae*: 1. Crabro cetratus *Shuck.*; 2. C. chrysostoma *Lep.*, freq.; 3. C. dives *H.-Sch.*, rare; 4. C. leucostoma *L.*, infreq.; 5. Psen atratus *Pz.*, freq.

Von Dalla Torre observed the following bees in the Tyrol.—

1. Andrena albicrus *K.* ♀ and ♂; 2. Osmia leucomelaena *K.* ♂ and ♀; 3. Prosopis borealis *Nyl.* ♀ and ♂; 4. P. nigrita *F.*; 5. P. bipunctata *Fbr.* (also recorded by Schletterer).

260. Kerria DC.

Homogamous pollen flowers.

922. K. japonica DC.—The flowers of this species are odourless and nectarless. Their mechanism is described as follows by Kirchner ('Beiträge,' p. 40). The anthers of the most external stamens ripen, and the stigmas mature in the bud. The inner stamens are short in proportion to their nearness to the centre of the flower. At first they are curved inwards, but later on become erect. The markedly diverging styles attain a length almost equal to that of the longest stamens. Self-pollination is therefore inevitable, and apparently takes place even before the flower opens. Focke states that the plant is self-sterile in Europe, but produces succulent fruits in Central China, its native region (Abh. natw. Ver., Bremen, xiv, 1897). The petals are at first of an orange-yellow colour, but become inconspicuous before the innermost anthers are ripe.

Visitors.—Kirchner did not see any.

261. Mespilus L.

White, conspicuous, homogamous hermaphrodite flowers; with half-concealed nectar secreted by a yellow fleshy ring in the receptacle, internal to the stamens.

923. M. germanica L.—Kirchner ('Flora v. Stuttgart,' p. 427) states that when the white flowers of this species open the five styles lie close together, but their stigmas are already mature, and directed outwards. The stamens are inclined inwards, and the innermost anthers are situated beneath the stigmas, while the others are at the same or a higher level, and as they dehisce introrsely automatic self-pollination must regularly take place. Crossing is only possible at later stages, when the stamens incline more outwards and the styles curve away from one another above.

262. Crataegus L.

White, protogynous flowers smelling like herring-brine (of trimethylamide). The nectar is half-concealed and secreted by a ring in the receptacle. On account of their odour the blossoms are referred to the class of nauseous flowers, visited by flies that are fond of putrefying substances.

924. C. Oxyacantha L. (Herm. Müller, 'Fertilisation,' pp. 240–1, 'Weit. Beob.,' II, p. 239; Kirchner, 'Flora v. Stuttgart,' p. 426; Loew, 'Blütenbiol.

Floristik,' pp. 388–9; Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234.)—According to Hermann Müller's account of this species the stigmas are already mature when the flower opens, and project from its centre; but the anthers are still unripe. The outer stamens are erect, but the inner ones are so bent inwards as to lie beneath the stigmas. After from one to two days the outermost anthers begin to dehisce, and get covered with pollen all round.

In cold dull weather the inner stamens remain incurved, while the outer ones project beyond the stigmas, and are bent inwards to an extent that renders automatic self-pollination easy. In warm sunshine, on the other hand, the stamens spread out away from the stigmas, so that the nectar previously concealed by the woolly hairs on the bases of the styles comes into view. Owing to the protogyny of the flower, nectar-seeking insects always effect crossing at the beginning of anthesis, and generally do so during later stages.

Visitors.—I observed the following in the island of Pellworm (4. 6. '93).—

A. Diptera. (*a*) *Muscidae*: 1. Scatophaga sp.; 2. Larger and smaller Muscids. (*b*) *Syrphidae*: 3. Helophilus pendulus *L.*; 4. Rhingia sp.; 5. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 6. Andrena albicans *Müll.* ♀; 7. Apis mellifica *L.*; 8. Bombus terrester *L.*; all skg.

Wüstnei noticed Andrena trimmerana *K.* in the island of Alsen.

Alfken records the following for Bremen.—

A. Diptera. (*a*) *Empidae*: 1. Empis ciliata *F.*; 2. E. opaca *F.*; 3. E. tesselata *F.* (*b*) *Muscidae*: 4. Cynomyia mortuorum *L.*; 5. Cyrtoneura hortorum *Fall.*; 6. Lucilia caesar *L.*; 7. Scatophaga stercoraria *L.* (*c*) *Syrphidae*: 8. Ascia lanceolata *Mg.*; 9. A. podagrica *F.*; 10. Eristalis arbustorum *L.*; 11. Helophilus pendulus *L.*; 12. Melanostoma mellina *L.*; 13. Syritta pipiens *L.*; 14. Syrphus pyrastri *L.*; 15. S. ribesii *L.* **B. Hymenoptera.** (*a*) *Apidae*: 16. Andrena albicans *Müll.* ♀; 17. A. albicrus *K.* ♀; 18. A. carbonaria *L.* ♂; 19. A. cineraria *L.* ♀; 20. A. fucata *Sm.* ♂; 21. A. humilis *Imh.* ♀; 22. A. nigroaenea *K.* ♀; 23. A. parvula *K.* ♀; 24. A. propinqua *Schenck* ♀; 25. A. trimmerana *K.* ♀; 26. A. varians *K.* ♀; 27. Bombus hortorum *L.* ♀, po-cltg.; 28. Eriades florisomnis *L.* ♀ and ♂; 29. Halictus calceatus *Scop.*, var. elegans *Lep.* ♀; 30. H. levis *K.* ♀; 31. H. morio *F.* ♀; 32. H. rubicundus *Chr.* ♂, po-cltg.; 33. H. sexnotatulus *Nyl.* ♀; 34. Osmia rufa *L.* ♀; 35. Psithyrus vestalis *Fourcr.* ♀, skg. (*b*) *Tenthredinidae*: 36. Pamphilius sylvaticus *L.* (*c*) *Vespidae*: 37. Vespa germanica *F.*; 38. V. sylvestris *Scop.* ♀.

Von Fricken saw a Cantharid (Cantharis haemorrhoidalis *F.*), a Cerambycid (Grammoptera ruficornis *F.*), and a Chrysomelid (Cryptocephalus violaceus *Laich.*) in Westphalia and East Prussia.

Loew observed the following in Brandenburg ('Beiträge,' p. 36).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Molorchus minor *L.* (*b*) *Dermestidae*: 2. Anthrenus scrophulariae *L.* (*c*) *Mordellidae*: 3. Anaspis frontalis *L.* (*d*) *Anobiidae*: 4. Anobium paniceum *L.* (*e*) *Scarabaeidae*: 5. Cetonia aurata *L.* (*f*) *Telephoridae*: 6. Cantharis rustica *Fall.*; 7. Malachius bipustulatus *L.* **B. Diptera.** (*a*) *Empidae*: 8. Empis sp. (*b*) *Muscidae*: 9. Anthomyia pluvialis *L.*; 10. Hydrotaea ciliata *F.* (*c*) *Syrphidae*: 11. Criorhina oxyacanthae *Mg.*, skg.; 12. Syritta pipiens *L.*, do. **C. Hymenoptera.** *Apidae*: 13. Andrena albicans *Müll.* ♀; 14. A. propinqua *Schenck* ♀; 15. A. tibialis *K.* ♀; 16. Halictus sexnotatus *K.* ♀; 17. Nomada ruficornis *L.*; 18. Osmia bicornis *L.* ♀; all skg.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (H. M.). (*b*) *Cerambycidae*: 2. Clytus mysticus *L.*, nect-lkg. (H. M.); 3. Grammoptera ruficornis *F.*,

freq., nect-lkg. (H. M.). (*c*) *Chrysomelidae*: 4. Clytra cyanea *F.*, damaging the petals (H. M.). (*d*) *Dermestidae*: 5. Anthrenus claviger *Er.*, occasional, nect-lkg. (H. M.); 6. A. pimpinellae *F.*, very freq., nect-lkg. (H. M.); 7. A. scrophulariae *L.*, freq., nect-lkg. (H. M.); 8. Attagenus pellio *L.*, nect-lkg. (H. M.). (*e*) *Mordellidae*: 9. Anaspis frontalis *L.*, nect-lkg. (H. M.); 10. Mordellistena abdominalis *F.*, do. (H. M.). (*f*) *Nitidulidae*: 11. Epuraea sp., nect-lkg. (H. M.); 12. Meligethes, very freq., nect-lkg. (H. M.). (*g*) *Oedemeridae*: 13. Asclera coerulea *L.* (H. M.). (*h*) *Scarabaeidae*: 14. Oxythyrea stictica *L.*, dvg. the anthers (H. M.). (*i*) *Telephoridae*: 15. Malachius elegans *Ol.* (?), dvg. the anthers (H. M.); 16. Cantharis testacea *L.* (H. M.). **B. Diptera.** (*a*) *Bibionidae*: 17. Bibio marci *L.*, skg. (H. M.); 18. Dilophus vulgaris *Mg.*, very freq. (H. M.). (*b*) *Empidae*: 19. Empis livida *L.*, in very large numbers, skg. (Kn.); 20. E. opaca *F.*, freq., skg. (H. M.); 21. E. punctata *F.*, do. (H. M.); 22. Microphorus velutinus *Macq.* (H. M.); 23. Tachydromia connexa *Mg.*, freq. (H. M.). (*c*) *Muscidae*: 24. Aricia serva *Mg.* (H. M.); 25. Cyrtoneura sp. (H. M.); 26. Echinomyia fera *L.* (H. M.); 27. Graphomyia maculata *Scop.* (H. M.); 28. Mesembrina meridiana *L.* (H. M.); 29. Onesia floralis *R.-D.*, skg. (H. M.); 30. O. sepulcralis *Mg.*, do. (H. M.); 31. Sarcophaga carnaria *L.*, do. (H. M.). (*d*) *Syrphidae*: 32. Eristalis arbustorum *L.*, very freq., skg. and po-dvg. (H. M.); 33. E. intricarius *L.*, skg. and po-dvg. (H. M.); 34. E. nemorum *L.*, do. (H. M.); 35. E. pertinax *Scop.*, do. (H. M.); 36. E. sepulcralis *L.*, do. (H. M.); 37. E. tenax *L.*, do. (H. M.); 38. Helophilus floreus *L.*, freq. (H. M.); 39. H. pendulus *L.*, do. (H. M.); 40. Pipiza notata *Mg.* (H. M.); 41. Rhingia rostrata *L.*, freq., skg. (H. M.); 42. Xylota segnis *L.* (H. M.). **C. Hymenoptera.** *Apidae*: 43. Andrena albicans *Müll.* ♀ and ♂, exceedingly numerous, skg. and po-cltg. (H. M.); 44. A. atriceps *K.* ♀ and ♂, do. (H. M.); 45. A. chrysosceles *K.* ♀, do. (H. M.); 46. A. connectens *K.* ♀, do. (H. M.); 47. A. dorsata *K.* ♀, do. (H. M.); 48. A. fulva *Schr.* ♀, do. (H. M., Kn.); 49. A. fulvicrus *K.* ♀ and ♂, skg. (H. M.); 50. A. gwynana *K.* ♀, skg. and po-cltg. (H. M.); 51. A. helvola *L.* ♀, skg. (H. M.); 52. A. nitida *Fourcr.* ♀ and ♂, exceedingly numerous, skg. and po-cltg. (H. M.); 53. A. parvula *K.* ♀, do. (H. M.); 54. A. schrankella *Nyl.* ♂, skg. (H. M., Budd.); 55. A. smithella *K.* ♀, do. (Budd.); 56. A. trimmerana *K.* ♀ and ♂, skg. and po-cltg. (H. M.); 57. A. varians *K.* ♀, do. (H. M.); 58. Apis mellifica *L.* ☿, freq., do. (H. M.); 59. Eucera longicornis *L.* ♂, skg. (H. M.); 60. Halictus cylindricus *F.* ♀, do. (H. M.); 61. Nomada ruficornis *L.* ♀ and ♂, do. (H. M.); 62. N. ruficornis *L.*, var. signata *Jur.* ♀ (H. M.).

Sickmann records the fossorial wasp Gorytes mystaceus *L.*, rare, for Osnabrück.

Schmiedeknecht noticed a bee (Andrena ferox *Sm.*) in Thuringia, and Krieger observed the following bees at Leipzig.—

1. Andrena albicans *Müll.*; 2. A. carbonaria *L.*; 3. A. fucata *Sm.*; 4. A. labialis *K.*; 5. A. nigroaenea *K.*; 6. A. tibialis *K.*; 7. A. trimmerana *K.*; 8. A. varians *K.*; 9. Nomada lineola *Pz.*; 10. N. succincta *Pz.*

Friese saw the bee Andrena combinata *Chr.*, one ♀, in Baden.

Schenck observed a wasp (Odynerus melanocephalus *Gmel.*) in Nassau, and Schiner the following flies in Austria.—

(*a*) *Stratiomyidae*: 1. Stratiomys furcata *F.* (*b*) *Syrphidae*: 2. Criorhina asilica *Fall.*, freq.; 3. C. berberina *F.*, rare; 4. C. floccosa *Mg.*; 5. C. oxycanthae *Mg.*, rare; 6. Mallota fuciformis *F.*; 7. Plocota apiformis *Schr.*, very rare. (*c*) *Therevidae*: 8. Thereva praecox *Egg.*

Redtenbacher noticed the following beetles in Austria.—

(*a*) *Cantharidae*: 1. Cantharis sp. (*b*) *Chrysomelidae*: 2. Cryptocephalus lobatus *F.* (*c*) *Dermestidae*: 3. Hadrotoma nigripes *F.*, rare.

MacLeod (Flanders) observed Apis, a short-tongued bee, 2 hover-flies, an Empid, a Muscid, and 8 beetles (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 305): also

(Pyrenees) a short-tongued bee, a beetle, and 2 flies (op. cit., iii, 1891, pp. 433–43). H. de Vries saw the honey-bee in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

In Dumfriesshire, Apis (freq.), a humble-bee, a Dolichopodid, and another fly were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 64).

Hermann Müller also observed extra-floral nectaries on the hawthorn: a sweet sap sometimes oozes from the tips of the young twigs, which is licked by bees (Anthophora pilipes *F.* ♂, Bombus terrester *L.* ♀, Andrena sp. ♂) and wasps (Odynerus parietum *L.* ♀).

H. Schütte (Elsfleth) saw large numbers of wasps (Vespa germanica *F.*) attracted by the juice exuding from the Psylla larvae which live on the hawthorn. He also noticed a humble-bee (Bombus terrester *L.*) licking this juice.

925. C. monogyna Jacq.—*The flowers of this species agree with those of* C. Oxyacantha as regards their mechanism.

VISITORS.—I observed the same insects in the island of Pellworm as for C. Oxyacantha (q. v.).

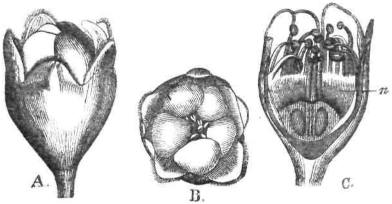


FIG. 122. *Cotoneaster integerrima, Medic.* (after Herm. Müller). *A.* Flower seen from the side and somewhat obliquely from above. *B.* The same, seen from above. *C.* The same, in longitudinal section. (× 7.) *n*, nectary.

263. Cotoneaster Rupp.

Flowers white or red; homogamous or protogynous; with concealed nectar secreted by the fleshy inner wall of the receptacle.

926. C. integerrima Medic. (=C. vulgaris *Lindl.*, and Mespilus Cotoneaster *L.*). (Herm. Müller, 'Alpenblumen,' pp. 214–15; Schulz, 'Beiträge,' II, pp. 70–1.)—The blossoms of this species are wasp flowers, with persistent stigmas. They are protogynous in the Alps, but homogamous to protogynous at Halle and in North Thuringia (Schulz). The petals and stamens bend so closely together over the nectar as to leave but a small passage of access. In the protogynous flowers crossing is effected by insect visitors before the anthers are ripe; in the homogamous ones self-pollination is inevitable, for the stamens are situated just under the anthers of the permanently incurved stamens.

VISITORS.—Herm. Müller, in the Alps, only noticed a wasp (Polistes biglumis *L.*). Schulz (Central Germany) observed not only wasps, but also several other Hymenoptera, together with some flies and beetles.

Morawitz (St. Petersburg) saw the bee Andrena fucata *Sm.*

927. C. nigra Wahlenb. (=Crataegus nigra *Waldst. et Kit.*, and Mespilus nigra *Willd.*).—Focke says that when anthesis is over in this species the white colour of the petals changes into pink.

264. Amelanchier Medic.

Flowers white; homogamous, protogynous, or protandrous; either with exposed nectar, or yielding only pollen (?).

928. A. vulgaris Moench (=A. rotundifolia *C. Koch*, Mespilus Amelanchier *L.*, and Aronia rotundifolia *Pers.*). (Herm. Müller, 'Alpenblumen,' pp. 213–14; Schulz, 'Beiträge,' II, pp. 70, 72; Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871.)—Both in the Alps, and according to Schulz in Central Germany, the flowers of this species are protandrous, sometimes to so marked an extent that the stigmas do not become receptive till all the anthers have dropped off. The nectar is exposed, and therefore accessible even to short-tongued insects. Visitors effect crossing in flowers which exhibit well-marked protandry, but where this is less marked, self-pollination may also take place, and this may be automatically effected by the fall of pollen on the stigmas, should insect-visits fail. Ricca describes the flowers as protogynous and devoid of nectar, and says that the four stamens develop in succession.

VISITORS.—Herm. Müller saw 7 beetles, a Hymenopterid, 2 Muscids, and 4 Syrphids in the Alps. Schulz observed flies, Hymenoptera, and beetles in Central Germany.

929. A. canadensis Torrey et Gray (=A. Botryapium *DC.*). (Kirchner, 'Beiträge,' pp. 38–9.)—The flowers of this species are white, and aggregated into conspicuous racemose inflorescences: their odour resembles that of Prunus Padus. Kirchner, for cultivated shrubs, describes the mechanism of the flowers as follows.—They are slightly protogynous, as when they open the five stigmas are mature, and occupy the middle of the flower, projecting 1–2 mm. beyond the still unripe anthers. Before complete expansion, however, the outermost anthers dehisce, and their filaments become erect, attaining the level of the stigmas, but at the same time diverging so as to be several millimetres from them. The inner stamens subsequently behave in the same way. Automatic self-pollination can easily take place in the obliquely placed flowers by fall of pollen on the stigmas. Secretion of nectar was not observed, probably however only because the weather was dull during the days when the observations were made. The fact that the inner side of the receptacle and the bases of the styles are coated with hairs allows us to infer that nectar is actually secreted by the former.

265. Cydonia Tourn.

Flowers reddish-white, and of considerable size; protogynous or homogamous; with half-concealed nectar, secreted by a fleshy ring at the base of the style.

930. C. japonica Pers. (=Chaenomeles japonica *Lindl.*). (Herm. Müller, 'Weit. Beob.,' II, p. 288; Stadler, 'Beiträge'; Focke, Abh. natw. Ver., Bremen, xiv, 1897, p. 303.)—Hermann Müller says that the flowers of this species are homogamous; Stadler describes them as protogynous, with a style that varies in length.

When the homogamous flowers open the anthers of the outer stamens dehisce, while those of the inner ones remain for some time beneath the receptive stigmas. As most of the visitors settle in the middle of the flower, and therefore touch the stigmas first, they regularly effect crossing. Only the honey-bee usually pushes in between the petals and stamens to reach the nectar, and so may effect self-pollination as well. Failing insect-visits, Stadler says that automatic self-pollination is possible, while Focke and Waite state that the species is undoubtedly self-fertile. Large fruits often contain only empty pips.

Focke describes the species as andromonoecious. When hermaphrodite flowers are dusted with pollen taken from the male flowers of the same plant they are almost always sterile, though they are fertile with pollen taken from another plant.

VISITORS.—Herm. Müller observed the following.—

A. Coleoptera. *Coccinellidae*: 1. Rhizobius litura *F.*, creeping about in the flowers. **B. Diptera.** *Muscidae*: 2. Lucilia cornicina *F.* **C. Hymenoptera.** *Apidae*: 3. Andrena albicans *Müll.* ♀, vainly searching for nectar, and then po-dvg.; 4. A. fulva *Schr.* ♀, po-cltg.; 5. A. gwynana *K.* ♀, do.; 6. Anthophora pilipes *F.* ♂ and ♀, skg.; 7. Apis mellifica *L.* ☿, generally skg., now and then also po-cltg.; 8. Bombus muscorum *F.* ♀, skg.; 9. B. pratorum ♀ and ☿, persistently skg.; 10. B. rajellus *K.* ♀, skg.; 11. B. terrester *L.* ♀, persistently skg.; 12. Halictus rubicundus *Chr.* ♀, po-cltg.

Alfken noticed the following bees at Bremen:—1. Bombus agrorum *F.* ♀; 2. B. derhamellus *K.* ♀; 3. B. lucorum *L.* ♀ and ☿; 4. Halictus calceatus *Scop.* ♀.

Schletterer, at Pola, saw the southern humble-bee Bombus argillaceus *Scop.*, flying about the flowers on quiet sunny days in January.

931. C. vulgaris Pers. (= Pyrus Cydonia *L.*). (Dodel-Port, 'Biol. Atlas d. Botanik'; Kirchner, 'Flora v. Stuttgart,' p. 428.)—The large reddish-white flowers of this species are protogynous. The nectar is protected against small unbidden guests by hairs on the style, and by the incurved bases of the filaments. Small creeping insects are kept out by the recurved sepals, which are covered with glandular hairs below, and also by the thick hairs on the bases of the petals. In other respects the mechanism agrees with that of Crataegus Oxyacantha. Automatic self-pollination is not excluded.

VISITORS.—Loew observed a bee (Halictus nitidiusculus *K.* ♀), po-cltg., in the Berlin Botanic Garden.

266. Pyrus L.

White or red protogynous flowers of considerable size; with half concealed nectar secreted by the receptacle.

932. P. Malus L. (Hildebrand, 'D. Geschlechts-Vert. b. d. Pfl.,' p. 60; Herm. Müller, 'Fertilisation,' p. 238; Kirchner, 'Beiträge,' pp. 36–8; Waite, 'Pollination of Pomaceous Fruits.')—Hildebrand was the first to figure the projecting position of the stigmas owing to which cross-pollination is favoured, and Hermann Müller first noticed protogyny in this species. To Kirchner we are indebted for the most exhaustive study of the flower mechanism. The size of the widely expanded reddish-white or rose-coloured blossoms varies with the variety; in small-flowered ones the average diameter is 38 mm., in large-flowered ones 49 mm. During the day

the blossoms possess only a slight odour of honey; but at night (according to Dr. Steudel of Stuttgart) they exhale an agreeable fragrance which attracts numerous Noctuids. The erect stamens are at first crowded together in the middle of the flower. Their unripe yellow anthers are either at the same level as the five already mature stigmas, or (as figured by Hildebrand) as much as 5 mm. below them. About two days after the bud has opened the anthers of the outer stamens begin to dehisce, and afterwards those of the inner stamens. Meanwhile the stamens diverge but little, so that in varieties where they are long automatic self-pollination can readily take place. This may also occur when the flower fades, for at this stage the styles curve outwards to such an extent that the stigmas are brought into contact with the but slightly diverging stamens. Anthesis lasts from five to six days. The interior of the flower is usually exposed without any protection to the action of rain, to the influence of which it appears to be very sensitive. Crossing is necessary for the production of a good crop. Waite says that self-pollinated flowers but rarely set fruits (cf. p. 392).

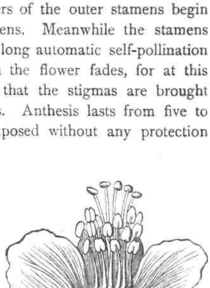


FIG. 123. *Pyrus Malus, L.* (after Hildebrand). Flower seen from the side; the stigmas projecting beyond the anthers.

VISITORS.—I noticed the following in my garden ('Bloemenbiol. Bijdragen').—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.* (14.5.'96); 2. Syrphus balteatus *Deg.* (27.5.'96); both skg. and po-dvg. **B. Hymenoptera.** *Apidae*: 3. Andrena parvula *K.* ♀, skg. and po-cltg.

Herm. Müller noticed the following.—

A. Diptera. (*a*) *Bibionidae*: 1. Dilophus vulgaris *Mg.*, in large numbers, skg. (*b*) *Bombyliidae*: 2. Bombylius major *L.*, skg. (*c*) *Empidae*: 3. Empis livida *L.*, skg. (*d*) *Muscidae*: 4. Onesia floralis *R.-D.*, skg. (*e*) *Syrphidae*: 5. Rhingia rostrata *L.*, exceedingly numerous, mostly skg., but also po-dvg.; 6. Syrphus pyrastri *L.*, skg. and po-dvg. **B. Hymenoptera.** (*a*) *Apidae*: 7. Andrena albicans *Müll.* ♂ and ♀, skg. and po-cltg.; 8. Anthophora pilipes *F.* ♀, do.; 9. Apis mellifica *L.* ☿, do.; 10. Bombus agrorum *F.* ♀, very common, do.; 11. B. hortorum *L.* ♀, do.; 12. B. lapidarius *L.*, do.; 13. B. terrester *L.* ♀, do.; 14. Halictus sexnotatus *K.* ♀, skg.; 15. Osmia rufa *L.* ♂, do. (*b*) *Formicidae*: 16. Several species, freq., skg.

Alfken, at Bremen, noticed a dragon-fly (Agrion minimum *Harr.*), freq., busy about the flowers, though the nature of its activity was not determined; also the following bees.—

1. Andrena albicans *Müll.* ♀; 2. A. albicrus *K.* ♀; 3. A. convexiuscula *K.* ♀; 4. A. varians *K.* ♀; 5. Bombus agrorum *F.* ♀; 6. B. hortorum *L.* ♀; 7. B. terrester *L.* ♀; 8. Halictus calceatus *Scop.* ♀; 9. H. levis *K.* ♀; 10. Osmia rufa *L.* ♀ and ♂; 11. Podalirius acervorum *L.* ♀.

The following were recorded by the observers and at the places stated.—

Krieger (Leipzig), a bee (Bombus hortorum *L.* ♀). Smith (England), a bee (Andrena fulva *Schr.*). Plateau (Belgium), bees (Apis, Andrena fulva *Schr.*, and Bombus terrester *L.*), a wasp (Vespa germanica *F.*), and flies (Calliphora vomitoria *L.*, Musca domestica *L.*, Lucilia caesar *L.*, and Eristalis tenax *L.*).

933. Pyrus communis L. (Herm. Müller, 'Fertilisation,' p. 239, 'Weit. Beob.,' p. 234; Kirchner, 'Beiträge,' pp. 35–6; Swayne, Trans. Hort. Soc., London, v, 1881, p. 208; Waite, 'The Pollination of Pear Fls.,' 'Pollination of Pomaceous Fruits,' 'The Fertilisation of Pear Fls.'; Knuth, 'Bloemenbiol. Bijdragen,' 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234.)—Hermann Müller was the first to call attention to the pronounced protogyny of the flowers of this species, and also briefly described their mechanism. Kirchner has given the following exhaustive account of the same. The anthesis of individual flowers lasts from seven to eight days. They possess an odour like that of hawthorn (due to trimethylamide), or, as Kirchner puts it, smell like cockchafers. There are many differences in size and form, according to the variety. Sometimes the flowers are bell-shaped, the petals inclining obliquely upwards; the average diameter in such cases is 18 mm. In other varieties the corolla spreads out flat, so that its diameter attains 42–48 mm. When the flowers open the central styles, with their already receptive stigmas, stand tolerably erect: all the stamens are so bent inwards that their red unripe anthers are crowded together in a heap in the middle, a little below the level of the stigmas. They guard the passage to the nectar. It follows that insect visitors usually alight upon the stigmas, and effect crossing if they have previously visited an older flower. This female stage lasts from two to four days, according to the weather. Meanwhile the outermost stamens gradually erect themselves, diverge obliquely outwards, and open their anthers. The inner stamens in turn behave in the same way, till in from five to seven days all the anthers have dehisced. The petals have sometimes been shed before the anthers of the innermost five stamens have opened. When the flower fades the stamens retain their divergent position, but the styles curve away from one another so as to bring the stigmas into contact with the shrivelled anthers. Since some pollen still clings to these, automatic self-pollination is effected. The flowers are not protected against rain, but are not very sensitive to its influence.

Cross-pollination is absolutely essential. This was first proved by George Swayne, and confirmed by Merton B. Waite. The latter states that, as a rule, perfect fruits only result from crossing, while pollen from another tree of the same variety has no more effect than that of the same flower.

Waite drew the following conclusions from his pollination experiments.—

1. Many of the common varieties of pears require to be crossed, and produce imperfect fruits or none at all when fertilized with their own pollen.

2. Some varieties are fertile with their own pollen.

3. In effecting crossing it is not sufficient to use pollen from another tree of the same variety, for this is not more effective than the pollen of the same tree. It is necessary to make use of pollen from another variety.

4. This ineffectiveness of pollen is not absolute, but is due to want of affinity between the pollen and ovules of the same variety.

5. It follows that pollen taken from two varieties may be perfectly ineffective when transferred, respectively, to the stigmas of flowers of the same variety, but each may produce excellent results when applied to stigmas of the other variety.

11. Pears resulting from self-fertilization contain imperfectly formed seeds, that are usually quite vestigial. The fruits that result from crossing contain well-developed healthy seeds.

12. Even in varieties which are fertile with their own pollen that of other varieties is more efficient, and when crossing is not prevented by the exclusion of insects most of the fruits seem to result from it.

13. Typical fruits, and, as a rule, the largest and best examples from all the varieties, are the result of crossing, whether the varieties are self-sterile or self-fertile.

Waite extended his experiments to apples and quinces. The varieties of the former exhibit even a greater tendency towards infertility when dusted with their own pollen than is the case with pears. The quince, on the other hand, is almost equally fertile with self- and cross-pollination.

VISITORS.—Herm. Müller (H. M.) in Westphalia, and myself (Kn.) in Schleswig-Holstein, observed the following.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella conglobata *L.*, nect-lkg. (H. M.). (*b*) *Curculionidae*: 2. Rhynchites aequatus *L.*, nect-lkg. (H. M.). (*c*) *Nitidulidae*: 3. Meligethes, freq. (H. M.). (*d*) *Phalcridae*: 4. Olibrus aeneus *F.*, nect-lkg. (H. M.). **B. Diptera.** (*a*) *Muscidae*: 5. Anthomyia radicum *L.* ♂ and ♀, very freq., skg. (H. M.); 6. A. sp. (Kn.); 7. Calliphora erythrocephala *Mg.*, skg. (H. M.); 8. Lucilia cornicina *F.*, do. (H. M., Kn.); 9. Musca corvina *F.*, do. (H. M.); 10. M. domestica *L.*, do. (H. M., Kn.); 11. Pollenia rudis *F.*, do. (H. M.); 12. P. vespillo *F.*, do. (H. M.); 13. Sarcophaga carnaria *L.* (Kn.); 14. Scatophaga merdaria *F.*, skg. and po-dvg. (H. M.); 15. Sepsis sp., skg. (H. M.). (*b*) *Syrphidae*: 16. Ascia podagrica *F.*, freq., skg. and po-dvg. (H. M.); 17. Eristalis arbustorum *L.*, skg. and po-dvg. (H. M.); 18. E. intricarius *L.*, do. (H. M.); 19. E. nemorum *L.*, freq., do. (H. M.); 20. E. tenax *L.*, do. (H. M., Kn.); 21. Melanostoma mellina *L.*, skg. and po-dvg. (H. M.); 22. Rhingia rostrata *L.*, do. (Kn.); 23. Syritta pipiens *L.*, do. (H. M., Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 24. Andrena albicans *Müll.* ♀ and ♂, freq., skg. and po-cltg. (H. M., Kn.); 25. A. collinsonana *K.* ♀, do. (H. M.); 26. A. gwynana *K.* ♀, do. (H. M., Kn.); 27. A. parvula *K.* ♀, do. (H. M., Kn.); 28. Apis mellifica *L.* ☿, do. (H. M., Kn.); 29. Bombus terrester *L.* ♀, skg. (H. M.); 30. Halictus rubicundus *Chr.* ♀, skg. and po-cltg. (H. M.). (*b*) *Formicidae*: 31. Lasius niger *L.* ☿, nect-lkg. (H. M.). (*c*) *Tenthredinidae*: 32. Dolerus gonager *F.*, occasional, skg. (H. M.); 33. Nematus capraeae *L.* (=Nematus gallicola *Steph.-E.*), in large numbers, skg. (H. M.). **D. Thysanoptera.** 34. Thrips, freq. (H. M.).

Alfken noticed the following bees at Bremen:—1. Andrena nigroaenea *K.* ♂; 2. A. varians *K.* ♀; 3. Bombus agrorum *F.* ♀; 4. B. lucorum *L.* ♀.

934. P. salicifolia L. (Kirchner, 'Beiträge,' p. 38.)—This oriental species was studied by Kirchner in the Hohenheim Botanic Garden. He found its flowers to be protogynous, and to agree in other respects with those of P. communis.

267. Sorbus L.

Flowers white or rose-red in colour, and aggregated into dense panicles; homogamous, protogynous, or protandrous; with half-concealed nectar secreted by a ring at the base of the style.

935. S. Aucuparia L. (Herm. Müller, 'Fertilisation,' pp. 239–40; Warnstorf, Schr. natw. Ver., Wernigerode, xi, 1896.)—Hermann Müller describes the flowers of this species as protogynous, agreeing as regards their mechanism with those of Crataegus Oxyacantha, which they also resemble in odour (that of trimethylamide). As many flowers are aggregated into large conspicuous inflorescences, insect visitors

are numerous. Warnstorf describes the pollen-grains as white in colour, irregular, rounded to ellipsoidal, almost smooth, about 37 μ long and 25 μ broad.

VISITORS.—Herm. Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) ('Bloemenbiol. Bijdragen'), have observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.*, skg. (H. M.). (*b*) *Chrysomelidae*: 2. Lochmaea sanguinea *F.*, skg. (H. M.). (*c*) *Curculionidae*: 3. Apion, skg. (H. M.); 4. Phyllobius maculicornis *Germ.*, skg. (H. M.). (*d*) *Dermestidae*: 5. Attagenus pellio *L.*, occasional (H. M.); 6. Byturus sp., by the hundred (H. M.). (*e*) *Elateridae*: 7. Agriotes aterrimus *L.* (H. M.); 8. Corymbites holosericeus *Oliv.* (H. M.); 9. Dolopius marginatus *L.* (H. M.); 10. Limonius cylindricus *Payk.* (H. M.); 11. L. parvulus *Pz.* (H. M.). (*f*) *Mordellidae*: 12. Anaspis rufilabris *Gylh.* (H. M.). (*g*) *Nitidulidae*: 13. Epuraea, by the hundred (H. M.); 14. Meligethes, do. (H. M.). (*h*) *Scarabaeidae*: 15. Cetonia aurata *L.*, dvg. all the parts of the flowers (H. M.); 16. Melolontha vulgaris *F.*, do. (H. M.). (*i*) *Telephoridae*: 17. Malachius aeneus *F.*, nect-lkg. and dvg. the anthers (H. M.). (*k*) *Tenebrionidae*: 18. Microzoum tibiale *F.* (H. M.). **B. Diptera.** (*a*) *Bibionidae*: 19. Dilophus vulgaris *Mg.*, freq., skg. (H. M.). (*b*) *Conopidae*: 20. Myopa testacea *L.* (H. M.). (*c*) *Empidae*: 21. Empis livida *L.*, freq., skg. (H. M.); 22. E. rustica *Fall.*, do. (H. M.). (*d*) *Muscidae*: 23. Echinomyia fera *L.* (H. M.); 24. Lucilia caesar *L.*, skg. and po-dvg. (Kn.); 25. Musca domestica *L.*, do. (H. M.); 26. Onesia floralis *R.-D.*, freq., skg. (H. M.); 27. Sarcophaga carnaria *L.*, skg. and po-dvg. (Kn.); 28. Scatophaga merdaria *F.*, freq., skg. (H. M.); 29. S. stercoraria *L.*, do. (H. M., Kn.); 30. Sepsis, freq. (H. M.). (*e*) *Syrphidae*: 31. Eristalis arbustorum *L.*, freq., skg. and po-dvg. (H. M.); 32. E. horticola *Deg.*, do. (H. M.); 33. E. nemorum *L.*, do. (H. M.); 34. E. pertinax *Scop.*, do. (Kn.); 35. E. tenax *L.*, do. (Kn.); 36. Helophilus floreus *L.*, do. (Kn.); 37. Melanostoma mellina *L.*, do. (Kn.); 38. Rhingia rostrata *L.*, do. (H. M.); 39. Syritta pipiens *L.*, do. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 40. Andrena albicans *Müll.* ♂, skg. (H. M., Budd.); 41. A. albicrus *K.* ♀ and ♂, skg. and po-cltg. (H. M.); 42. A. atriceps *K.* ♀, do. (H. M.); 43. A. convexiuscula *K.* ♀, do. (H. M.); 44. A. dorsata *K.* ♀ and ♂, do. (H. M.); 45. A. smithella *K.* ♀, po-cltg. (H. M.); 46. Apis mellifica *L.* ☿, very freq., skg. and po-cltg. (H. M., Kn.); 47. Halictus rubicundus *Chr.* ♀, skg. and po-cltg. (H. M.); 48. H. zonulus *Sm.* ♀, do. (H. M.); 49. Nomada ruficornis *L.* ♀ and ♂, skg. (H. M.); 50. N. ruficornis *L.*, var. signata *Jur.* ♀, skg. (H. M.). (*b*) *Formicidae*: 51. Formica pratensis *Deg.* ♀ and ♂, freq., skg. (H. M.); 52. F. rufa *L.* ☿, nect-lkg. (H. M.); 53. Lasius niger *L.* ♀, freq., skg. (H. M.); 54. Myrmica sp. ☿, do. (H. M.). **D. Lepidoptera.** *Rhopalocera*: 55. Thecla rubi *L.*, skg. (Budd.).

Loew noticed the following in Brandenburg ('Beiträge,' p. 37).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *F.* **B. Diptera.** (*a*) *Empidae*: 2. Empis punctata *Mg.*, skg.; 3. E. tessellata *F.*, do. (*b*) *Stratiomyidae*: 4. Odontomyia tigrina *F.* (*c*) *Syrphidae*: all skg.; 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. E. tenax L.; 8. Helophilus floreus *L.*; 9. H. pendulus *L.*; 10. H. trivittatus *F.*; 11. Syrphus corollae *F.* **C. Hymenoptera.** *Apidae*: all skg.; 12. Andrena fulva *Schr.* ♀; 13. A. nigroaenea *K.* ♀; 14. A. varians *K.*, var. helvola *L.* ♀.

Alfken records the following for Bremen.—

A. Coleoptera. (*a*) *Scarabaeidae*: 1. Cetonia aurata *L.*; 2. C. floricola *Hbst.* (*b*) *Cerambycidae*: 3. Cerambyx scopolii *Fuessl.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Andrena albicans *Müll.* ♀ and ♂; 5. A. albicrus *K.* ♀; 6. A. apicata *Sm.* ♀; 7. A. cingulata *F.* ♂; 8. A. flavipes *Pz.* ♀; 9. A. nigroaenea *K.* ♀; 10. A. nitida *Fourcr.* ♀; 11. A. praecox *Scop.* ♀; 12. A. tibialis *K.* ♀; 13. A. varians *K.* ♀; 14. Bombus agrorum *F.* ♀; 15. B. terrester *L.* ♀; 16. Halictus nitidiusculus *K.* ♀. (*b*) *Vespidae*: 17. Odynerus parietum *L.* ♂.

MacLeod saw a humble-bee in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 434); and Apis in Flanders (op. cit., vi, 1894, p. 307). Redtenbacher noticed the Cerambycid Rhopalopus insubricus *Germ.*

H. de Vries noticed 2 bees (Apis mellifica *L.* ☿, and Andrena pilipes *F.* ♀) in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875).

In Dumfriesshire, a humble-bee, 2 Empids, 3 Muscids, a hover-fly, a Dolichopodid, Meligethes, and undetermined beetles were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 64).

936. S. Chamaemespilus Crantz (=Pyrus Chamaemespilus *Ehrh.*, Mespilus Chamaemespilus *L.*, and Crataegus Chamaemespilus *Jacq.*). (Schulz, 'Beiträge,' II, p. 72.)—Schulz describes the rose-red flowers of this species as either homogamous or more or less protogynous. As the stigmas are situated in the line of fall of the pollen, automatic self-pollination frequently occurs, but this can be dispensed with during sunny weather, for nectar is then secreted in great abundance, and the flowers are visited by numerous nectar-sucking or pollen-devouring insects (long-tongued flies, small beetles, and particularly bees and wasps). Flowers that have already lost their petals, but which are still fresh enough to secrete plenty of nectar, are also sucked by short-tongued flies and the larger beetles. These are kept from visiting the younger flowers by the erect petals, which are tolerably close together.

937. S. scandica Fries.—

VISITORS.—Loew observed the following visitors in the Berlin Botanic Garden.—

A. Coleoptera. *Malacodermata*: 1. Dasytes flavipes *F.*, nect-lkg. **B. Diptera.** *Empidae*: 2. Empis trigramma *Mg.*, skg. **C. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.

XXXV. ORDER *SAXIFRAGEAE* Vent.

(including PHILADELPHACEAE Don and GROSSULARIACEAE DC. (=RIBESIACEAE Endl.)).

268. Saxifraga Tourn.

LITERATURE.—Hermann Müller, 'Fertilisation,' pp. 243–5, 'Alpenblumen,' pp. 109–11; Engler u. Prantl, 'D. nat. Pflanzenfam.,' III, 209, Bot. Ztg., Leipzig, xxvi, 1868, pp. 833–42.

Flowers pure white or yellow to purple-spotted or dirty yellow in colour, rarely rose-red or blue. The nectar is exposed, rarely half-concealed, and is secreted by the outer wall of the ovary. This position attracts numerous short-tongued insects, among which flies predominate to such an extent that most of the species must be placed in flower class **F**. Owing to the large number of visitors, many species are able to dispense with automatic self-pollination, which indeed is rendered nearly or quite impossible by the occurrence of more or less pronounced dichogamy. Most species are protandrous, but a few are protogynous (S. androsacea, S. muscoides, S. Seguieri). In the latter the flowers are considerably smaller in the first (female) than in the second (male) stage. After the stigmas shrivel the

flower increases to twice its original diameter or even more, so that the visits paid by any particular insect will usually be in the order most favourable for crossing.

We are indebted to A. Engler for an excellent monograph on the genus. He regarded all the species as protandrous. Treviranus (Bot. Ztg., Leipzig, xxi, 1863) had already observed the movement of the stamens towards the middle of the flower, and inferred that automatic self-pollination takes place. As some species of this genus possess nectar-guides, while others do not, Engler called in question the correctness of Sprengel's interpretation of these markings. Hermann Müller remarks in this connexion ('Fertilisation,' p. 243), that in plants where the nectar is sometimes fully exposed, and at other times concealed, there is very naturally a corresponding variation in the nectar-guides, so that this peculiarity of the genus cannot be regarded as opposed to Sprengel's view, while there is no other explanation to take its place.

938. **S. Aizoon** Jacq. (Herm. Müller, 'Alpenblumen,' pp. 100–2.)—The flowers of this species are markedly protandrous, and in the Alps self-pollination is almost or entirely prevented. The abundant pollen and readily accessible nectar

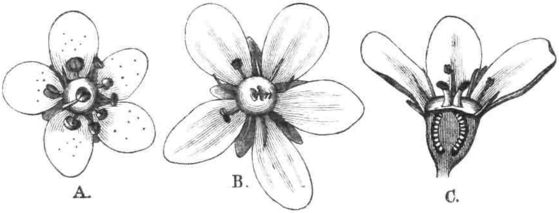


FIG. 124. *Saxifraga Aizoon, Jacq.* (after Herm. Müller). *A.* Flower at the beginning of the first (male) stage. *B.* The same, at the end of the first stage. *C.* Flower in the second (female) stage (×3½). *n*, nectary.

attract numerous visitors, especially flies. In Greenland, where insects are few, the flowers are also strongly protandrous, but here effective automatic self-pollination is ultimately possible by contact of the anthers (still covered with pollen) with the widely divergent stigmas (Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 27–9).

Visitors.—Herm. Müller observed (in the Alps) no fewer than 61 species of flies (including 37 Muscids); also 5 beetles, 11 Hymenoptera, and 10 Lepidoptera.

Loew saw the Syrphid Cheilosia modesta *Egg.* (?) in Switzerland ('Beiträge,' p. 56). MacLeod noticed a short-tongued Hymenopterid and 5 Muscids in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 420).

Loew observed 2 Syrphids in the Berlin Botanic Garden—1. Ascia podagrica *F.*, passing from flower to flower, hovering a considerable time over each, and then alighting to suck; 2. Melithreptus scriptus *L.*, do.

939. S. mutata L.—The flowers of this species secrete exposed nectar, and Stadler describes them as protandrous, though self-pollination is not excluded. The stamens at first move towards the centre, and later on away from it.

940. S. Burseriana L.—Kerner states that the flowers of this species are protogynous, but during the twelve days of anthesis the stamens move towards the centre, so that automatic self-pollination ultimately takes place.

941. S. caesia L. (Herm. Müller, 'Alpenblumen,' pp. 102–4; Engler, Bot. Ztg., Leipzig, xxvi, 1868.)—The blossoms of this species are fly flowers, secreting exposed nectar. Engler was the first to notice their protandry. Self-pollination is entirely prevented in the Alps.

VISITORS.—These are chiefly flies, of which Herm. Müller observed 15 species in three days, besides 3 beetles, 3 Hymenoptera, and 3 Lepidoptera.

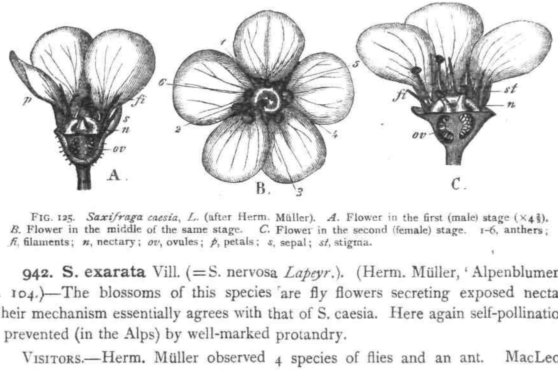


FIG. 125. *Saxifraga caesia*, *L.* (after Herm. Müller). *A.* Flower in the first (male) stage (×4⅔). *B.* Flower in the middle of the same stage. *C.* Flower in the second (female) stage. 1–6, anthers; *fi*, filaments; *n*, nectary; *ov*, ovules; *p*, petals; *s*, sepal; *st*, stigma.

942. S. exarata Vill. (=S. nervosa *Lapeyr.*). (Herm. Müller, 'Alpenblumen,' p. 104.)—The blossoms of this species are fly flowers secreting exposed nectar. Their mechanism essentially agrees with that of S. caesia. Here again self-pollination is prevented (in the Alps) by well-marked protandry.

VISITORS.—Herm. Müller observed 4 species of flies and an ant. MacLeod saw a fossorial wasp and a hover-fly in the Pyrenees.

943. S. oppositifolia L. (Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 29–33, Vet. Ak. Overs., Kjöbenhavn, 1886–7, p. 13; Herm. Müller, 'Alpenblumen,' pp. 98–100.)—The flowers of this species are variously described by Engler as protandrous, Axell as slightly protandrous, Ricca as homogamous, and Hermann Müller as protogynous (on the Piz Umbrail and the Albula). Schulz also observed protogyny, as did Warming in Greenland, and Lindman on the Dovrefjeld. Ekstam, on the other hand, noticed protandry in Nova Zemlia. The blossoms are Lepidopterid flowers with concealed nectar. Lindman observed large-flowered and small-flowered varieties on the Dovrefjeld. Failing insect-visits, self-pollination frequently takes place, and appears to be effective, for the flowers in Greenland set many fruits, despite the early anthesis and the lack of insects. Lindman also observed ripe fruits on the Dovrefjeld, but no visitors.

In Spitzbergen this species is sometimes seen as a creeping form, sometimes in dense clumps. According to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 1), it begins to bloom in the middle of June, and some plants continue to do so till September. Fruits were observed to be set from the middle of July (19. 7. '98) or the beginning of August (8. 8. '97) onwards. The flowers vary from 9 to 11 mm. in diameter, or exceptionally 18 to 20 mm. Ekstam describes them as faintly fragrant, dark-red to bright violet in colour, or sometimes white ('Blütenbiol. Beob. a. Spitzbergen,' p. 12). As to the development of the sexual organs the protogynous to homogamous flowers agree with those examined by Warming. Andersson and Hesselman (op. cit., p. 24)

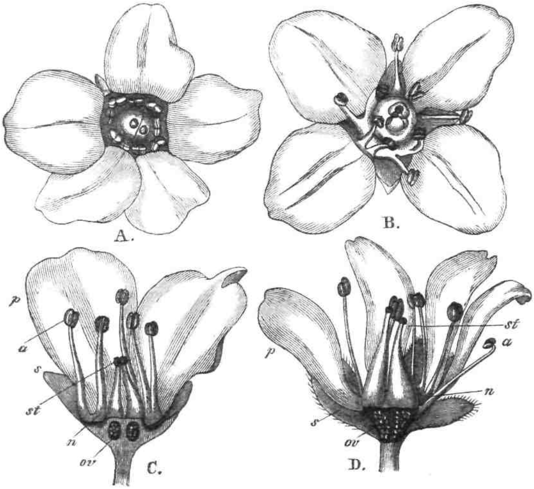


FIG. 126. *Saxifraga oppositifolia*, *L.* (after Herm. Müller). *A*. Newly opened flower, seen from above. *B*. Older flower, seen from above. *C*. Another older flower, in longitudinal section (× 5). *D*. Flower with mature stigmas and unripe anthers, partly in section (× 3½). *a*, anthers; *n*, nectary; *ov*, ovules; *p*, petals; *s*, sepals; *st*, stigmas.

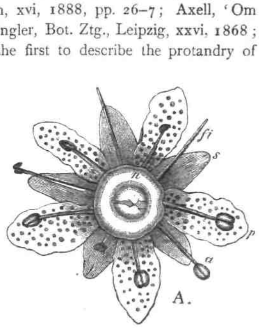
noticed distinct protogyny. Ekstam says that characteristic more or less closed flowers appear in August, with reduced stamens and greatly enlarged pistils.

Schulz observed gynodioecism in the Tyrol. The nectar is so deeply situated that short-tongued insects can reach it only with great difficulty or not at all, while it is conveniently placed for Lepidoptera.

VISITORS.—Herm. Müller noticed that Lepidoptera formed the majority of individuals (3 species), and also observed a beetle, a Syrphid, and 3 Muscids. Ricca saw a humble-bee and several Lepidoptera. Ekstam (Nova Zemlia) observed humble-

bees (the sole resort of which during the summer is this species) and flies. In Spitzbergen he noticed several small Muscids on three days during July. Schneider (Mus. Aarsh. Tromsø, xvii, 1895) saw Andrena sp. in the Christiania Botanic Garden. He further states (op. cit., p. 142) that humble-bees only play a subordinate part as pollinators in Arctic Norway.

944. **S. aizoides** L. (Herm. Müller, 'Fertilisation,' p. 245, 'Alpenblumen,' pp. 94–8; Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 26–7; Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 35; Engler, Bot. Ztg., Leipzig, xxvi, 1868; Schulz, 'Beiträge.')—Axell and Engler were the first to describe the protandry of this species, though Schulz states that the terminal flower is frequently female. The nectar is exposed, and the flower mechanism adapted to the visits of flies. According to Hermann Müller, cross-pollination, as the result of insect-visits, is ultimately secured by the slow successive development of the individual stamens and the stigmas. Self-pollination is not completely excluded. Warming states that in Greenland, Spitzbergen, and Finmark, the flowers are at first markedly protandrous, afterwards becoming homogamous. Ripe fruits were observed at



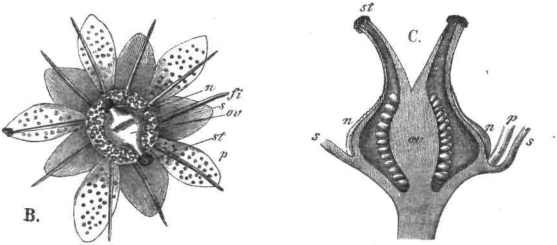


FIG. 127. *Saxifraga aizoides, L.* (after Herm. Müller). *A.* Flower in the first (male) stage, *B.* Flower in the second (female) stage (× 3½). *C.* The same in longitudinal section (× 7). *a*, anther; *fi*, filament; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

Jacobshavn and Franz-Josef's Fjord. Abromeit describes Greenland specimens as possessing the orange-red spots on the petals, marked more or less clearly ('Bot. Ergeb. von Drygalski's Grönlandsexped.'). Andersson and Hesselman saw sterile flowers in Beeren Island. They state that the species flowers in Spitzbergen from the first half of July till August and September, but whether fruits are set was not determined ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 28). Ekstam, for Spitzbergen, describes the flowers as being usually protandrous, though cases of homogamy were also noticed ('Blütenbiol. Beob. a. Spitzbergen,' p. 15). Ekstam says that the odourless flowers are 10–12 mm. in diameter in Nova Zemlia.

VISITORS.—Small flies and ants were seen in Nova Zemlia, but no visitors in Spitzbergen.

Herm. Müller observed in the Alps no fewer than 85 Diptera (mostly Muscidae), besides 8 beetles, 20 Hymenoptera, and 13 Lepidoptera; Loew saw a hover-fly in the same region ('Blütenbiol. Floristik,' p. 397). Lindman noticed flies, Hymenoptera, and a beetle on the Dovrefjeld. MacLeod saw 8 short-tongued Hymenoptera, a Phryganid, a beetle, 4 Syrphids, and 19 other Diptera in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 420–2).

945. S. Hirculus L. (Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, p. 25.)—Warming says that the flowers of this species are markedly protandrous in Spitzbergen. Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 27–8) say that this species flowers in Spitzbergen during the second half of July and in August; feebly developed flower-buds were noticed in Beeren Island on June 18, 1898. Fruits appear to be ripened with difficulty at the end of August or the beginning of September. The petals are bright yellow,

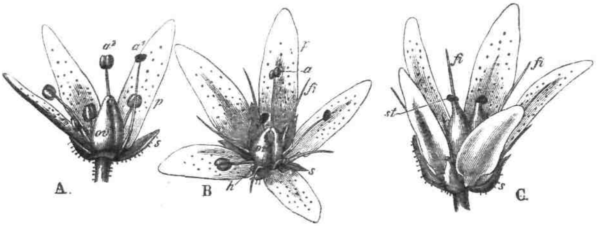


FIG. 128. *Saxifraga rotundifolia, L.* (after Herm. Müller). *A.* Flower at the beginning of the first (male) stage. *B.* Flower towards the end of the same stage. *C.* Flower in the second (female) stage (×4⅔). *a–a²*, anthers; *fi*, filament: *h*, drop of nectar; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

with a basal swelling on either side, and citron-yellow spots. There is marked protandry, according to Andersson and Hesselman, confirmed by Ekstam. Stocks with purely female flowers were seen, and also gynomonoecious transition forms. Ekstam thinks that the basal folds of the petals, the roots of the filaments, and the base of the ovary possibly secrete nectar. In Nova Zemlia, according to Ekstam, the diameter of the odourless, nectarless (?), slightly protandrous flowers is 12–25 mm.

VISITORS.—On seven days of July and August (1897) Ekstam noticed an extremely large number of flies. These insects have also been seen in Nova Zemlia.

946. S. rotundifolia L. (Herm. Müller, 'Fertilisation,' p. 245; 'Alpenblumen,' pp. 89, 90.)—The flowers of this species are white, spotted with purple-red, and secreting half-concealed nectar. They are so markedly protandrous that automatic self-pollination cannot take place. They belong to the class of fly flowers. Insect-visits necessarily bring about crossing, for even the smallest nectar-seeking guest touches the anthers of younger flowers, and one or both stigmas in those which are older.

VISITORS.—Herm. Müller observed almost exclusively flies (2 Empids, 7 Muscids, 5 Syrphids); also an Ichneumonid. Schiner mentions the Syrphid Sphegina clunipes *Fall.* as a common visitor.

947. **S. stellaris** L. (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 90–2.)—The flowers of this species are stellate, with half-concealed nectar. Stamens and carpels mature in the same order as in S. rotundifolia, but the times of ripening of the individual stamens overlap to a greater extent. Automatic self-pollination does not usually take place, but perhaps occurs in dull weather or if insect-visits fail. Schulz says that the terminal flower is often female. According to Ekstam, the flowers are protandrous in the Swedish Highlands at Dovre, and also in Nova Zemlia, while on the Ronde and Tronfjall they are almost homogamous.

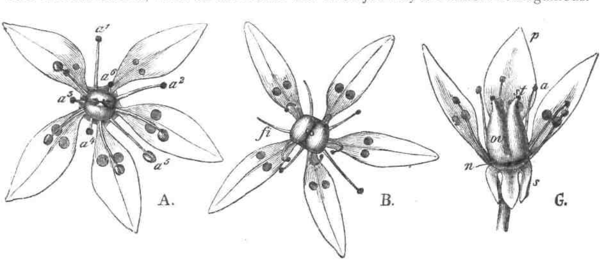


FIG. 129. *Saxifraga stellaris, L.* (after Herm. Müller). *A.* A bilaterally symmetrical flower in the middle of the first (male) stage. *B.* A radially symmetrical flower at the end of the same stage. *C.* Flower in the second (female) stage. *a–a'*, anthers; *fi*, filament; *n*, nectary; *ov*, ovary; *s*, sepal; *p*, petal; *st*, stigma.

On the Dovrefjeld, on the other hand, according to Lindman, the flowers are markedly protandrous, but on the Tronfjeld, and in Langluplad, they are almost homogamous, and self-pollination is ultimately possible. In Greenland Warming observed homogamy and protogyny as well as protandry (Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 10–14). He found ripe fruits on the Sukkestop. In 63° N. lat. there occurs a variety, *comosa* Poir., that propagates by rosettes of leaves, which fall off. These originate from flowers.

Abromeit also made observations on the variety in Greenland, and noticed properly developed terminal flowers, or else flowers with minute petals (var. *cryptopetala*) at the ends of rosette-bearing branches ('Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 33). The normal flower possesses white, clawed petals, with two yellow spots at the base of the lamina. The anthers vary in colour from white to pale violet and purple; the pollen is vermilion.

Ekstam says that in Spitzbergen the variety propagates entirely by rosette-shaped leaf-buds, which easily fall off and take root ('Blütenbiol. Beob. a. Spitzbergen,' p. 12). Andersson and Hesselman state that the process commences at the beginning of August and goes on for a considerable time ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 23).

VISITORS.—Herm. Müller observed flies, almost exclusively (a Dolichopodid, an Empid, 8 Muscids, 2 Syrphids); also occasional beetles, Lepidoptera, and Hymenoptera. In Dumfriesshire, an Empid, 3 Muscids, and 3 Syrphids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 72).

948. S. aspera DC. (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 92–3.)—The blossoms of this species secrete exposed nectar, and belong to the class of fly flowers. As Engler observed, they are markedly protandrous. Automatic self-pollination is as a rule excluded.

VISITORS.—Herm. Müller noticed 2 Muscids; and Loew (Pontresina) saw a Muscid.

949. S. bryoides L. (= S. aspera *L.*). (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 93–4.)—Engler was the first to observe protandry in this species. The flower mechanism completely agrees with that of S. aspera. Kerner states that anthesis lasts for eight days.

VISITORS.—Herm. Müller chiefly observed flies (an Empid, 6 Muscids, 2 Syrphids); also occasional beetles and Ichneumonids.

950. S. cuneifolia L. (Kirchner, 'Beiträge,' pp. 31–2.)—The flowers of this species secrete exposed nectar. Delpino was the first to call attention to their marked protandry. Kirchner says that the flower mechanism, as observed at Zermatt, comes nearest to that of S. stellaris. Self-pollination is excluded by protandry: it is only when all the anthers have shrivelled and dropped off that the styles separate and expose the stigmas.

VISITORS.—Kirchner observed 2 species of flies.

951. S. hieracifolia Waldst. et Kit.—The nectar is half-concealed in this species. Kerner, whose observations were made in the Tyrol, noticed that the peduncle bends downwards towards the end of anthesis, so that the stigmas are brought into the line of fall of the pollen, automatic self-pollination resulting. Warming found that self-pollination can also easily take place in Greenland, where the flowers remain more or less closed (Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 16–22). Ekstam says that in Nova Zemlia the odourless, inconspicuous, greenish-yellow flowers are markedly protandrous, and 5–10 mm. in diameter.

Andersson and Hesselman state that the species flowers in Spitzbergen from the beginning of July till the beginning of August ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 21–2). Fruits are regularly set, and are in some cases fully ripe by the end of August. Ekstam, for Spitzbergen, describes the flowers as 5–10 mm. in diameter, odourless, and protogynous to homogamous: the stigmatic surfaces separate and assume a glistening appearance before the anthers are completely ripe ('Blütenbiol. Beob. a. Spitzbergen,' pp. 10–11).

VISITORS.—Ekstam noticed a medium-sized fly in Spitzbergen.

952. S. Seguieri Spreng. (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 106–7.)—This species secretes exposed nectar, and its flower mechanism is adapted to the visits of flies. Unlike most others of the genus it exhibits marked protogyny, and the stigmas persist only for a short time. Self-pollination is excluded, for the outer anthers only begin to dehisce after the stigmas have shrivelled up.

VISITORS.—These are flies.

953. S. muscoides Wulf. (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 106–7.)—The flower mechanism of this species agrees with that of S. Seguieri.

Visitors.—Herm. Müller observed 6 flies, a beetle, an Ichneumonid, and a Lepidopterid.

MacLeod noticed 2 short-tongued Hymenoptera, a beetle, and 5 flies, in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 422–3).

954. S. androsacea L. (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 107–8.)—This is a third protogynous Alpine species, and its flower mechanism agrees with those of S. Seguieri and S. muscoides. In this case, however, self-pollination is ultimately possible, for the stigmas remain receptive till the dehiscence of the first anther.

Visitors.—Herm. Müller noticed a hover-fly (Eristalis tenax *L.*) at a height of over 3,000 m.

955. S. decipiens Ehrh. (=S. hypnoides *L.* and S. caespitosa *Sm.*). (Warming, Bot. Tids., Kjöbenhavn, xvi, 1888. pp. 18–22.)—Warming describes the flowers of this species as slightly protandrous, homogamous, or even protogynous. Self-pollination is possible and effective, for ripe fruits have been found in Spitzbergen, Beeren Island, &c. Besides hermaphrodite flowers, female ones have been observed in Spitzbergen, on the Dovrefjeld, and in Greenland.

Abromeit states that the species is widely distributed in Greenland up to a height of 5,000 ft. above sea-level, and is represented by several varieties ('Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 35). The calyx is covered with glandular hairs, sometimes black in colour, and sometimes yellow.

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Lucilia caesar *L.*; 2. Scatophaga scybalaria *L.* (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*, skg.; 4. Syritta pipiens *L.*, do. **B. Hymenoptera.** *Apidae*: 5. Halictus minutissimus *K.* ♀, skg.; 6. H. nitidiusculus *K.* ♀, do.

956. S. caespitosa L.—The nectar is exposed in this species. Lindman observed, on the Dovrefjeld, homogamous flowers in which effective self-pollination was possible, as evidenced by fruits. Ekstam states that the faintly fragrant flowers are 5–12 mm. in diameter in Nova Zemlia. Self-pollination is prevented in flowers that are either almost homogamous or very markedly protandrous, but it is possible in those which are protogynous-homogamous.

According to Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 30–1), this species is among those indigenous to Spitzbergen in which anthesis is prolonged. It begins when the snow melts in the middle of June, and continues all through the summer till the end of August, or even into September. In Beeren Island the earliest blossoms were noticed on June 13, 1898; fruits are ripened in abundance from about the second half of July. The observers mentioned regard the flowers as protogynous, but Ekstam describes them as strongly protandrous-homogamous ('Blütenbiol. Beob. a. Spitzbergen,' p. 18). They are 10–15 mm. in diameter, odourless, and white, yellowish-green or reddish in colour. After the anthers have completely ripened the stamens

bend over the matured stigmas in such a way that autogamy would seem to be inevitable. Andersson and Hesselman observed an apetalous variety, in which the petals were modified into stamens, the pollen of which was partially abnormal.

VISITORS.—Numerous flies were observed by Lindman on the Dovrefjeld. As frequent visitors in Spitzbergen Holmgren noticed the Ichneumonids Hemiteles septentrionalis *Holmgr.*, and Orthocentrus pedestris *Holmgr.*; also a Muscid, Aricia (Chortophila) megastoma *Bohem.* On seven different days of July and August Ekstam saw many small Diptera in Spitzbergen.

957. S. rivularis L. (Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 7–10.)—The inconspicuous flowers of this boreal and arctic species are, according to Lindman and Warming, at first slightly protogynous, and afterwards homogamous, self-pollination being easily possible. Fruits are set early and rapidly. Warming observed purely female plants with vestigial stamens in Spitzbergen.

Andersson and Hesselman describe the species as flowering in Spitzbergen from the beginning of July to the end of August; in Beeren Island open blossoms were noticed in favourable spots as early as June 18 ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 29–30). The pollen is normally developed, and fruits appear to ripen regularly. Ekstam says that in Spitzbergen the flowers are odourless, white or pale red in colour (bright red in some Beeren Island specimens),

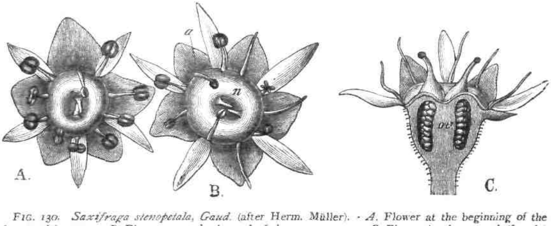


FIG. 130. *Saxifraga stenopetala, Gaud.* (after Herm. Müller). *A.* Flower at the beginning of the first (male) stage. *B.* Flower towards the end of the same stage. *C.* Flower in the second (female) stage, in section. *a*, outer stamen; *n*, nectary; *ov*, ovary.

and 6–8 mm. in diameter, or sometimes 5–10 mm. ('Blütenbiol. Beob. a. Spitzbergen,' pp. 17–18). In still incompletely open flowers, the anthers are beginning to dehisce, and the stigmas are papillose; homogamy may therefore be inferred.

According to Abromeit, several varieties have been recorded for Greenland, including *purpurascens* Lange with reddish petals ('Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 34–5).

VISITORS.—Ekstam noticed large and small flies on two days of July in Spitzbergen.

958. S. stenopetala Gaud. (=S. aphylla *Sternb.*). (Herm. Müller, 'Fertilisation,' p. 244, 'Alpenblumen,' pp. 108–9.)—In this markedly protandrous species self-pollination is excluded (cf. Fig. 130). The nectar is exposed, and the flower mechanism is adapted to flies.

VISITORS.—Flies have been observed.

959. S. adscendens L.—The nectar is exposed in this species. Kerner describes the flowers as protogynous. At first only the stigmas are mature, so that cross-pollination may take place; later on the outer anthers bend over the stigmas, and shed their pollen upon them, so that failing insect-visits automatic self-pollination may be effected. In the third stage of anthesis the stigmas shrivel up, while the inner anthers dehisce and offer their pollen to insect visitors.

Lindman says that, on the Dovrefjeld, the flowers are homogamous, and effectively autogamous.

960. S. controversa Sternb.—Kerner describes this species as trimonoecious.

961. S. longifolia Lapeyr.—The white blossoms of this species are aggregated into many-flowered inflorescences: the nectar is exposed. MacLeod describes them as protandrous in the Pyrenees, becoming homogamous towards the end of anthesis,

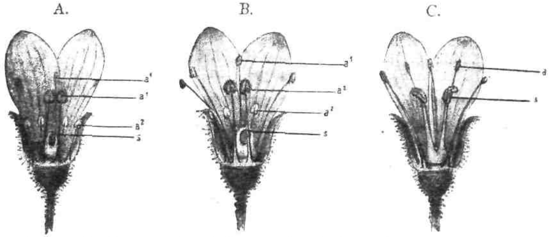


FIG. 131. *Saxifraga granulata*, *L.* (from nature). *A.* Flower in the first part of the first (male) stage: several of the outer anthers have dehisced, or are already empty, while the inner ones are still unripe, and the stigmas are immature. *B.* Flower in the second half of the same stage: all the outer anthers are empty, those of the inner whorl are partly covered with pollen, partly unripe, and the stigmas are still immature. *C.* Flower in the second (female) stage: all the anthers are empty, and the stigmas are mature. a^1 and a^2, outer and inner anthers; *s*, stigma.

so that automatic self-pollination is ultimately possible. Anthesis apparently lasts for several weeks, the various stages following one another very slowly.

VISITORS.—MacLeod observed a few Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 425).

962. S. ajugifolia L.—

VISITORS.—MacLeod observed 4 species of flies in the Pyrenees.

963. S. granulata L. (Sprengel, 'Entd. Geh.,' pp. 242–4; Herm. Müller, 'Weit. Beob.,' I, pp. 296–7; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 154, 'Bloemenbiol. Bijdragen.')—The white flowers of this species are markedly protandrous. Sprengel describes the green nectary as being situated on the upper side of the ovary. The calyx holds the petals so closely together that they form a tube, in the base of which the nectar is sheltered from rain. When the flower opens the anthers are still unripe, and the filaments short. Two of the latter rapidly elongate, and assume an oblique position, in such a way that their anthers, which have meanwhile dehisced, lie immediately above the pistil. When these stamens have shed their pollen, they bend back towards the petals, and two or

three others take their place. The pollen continues to be shed for about three days, and during this time the styles with their immature stigmas lie close together. It is only after the anthers have emptied themselves that the styles elongate and diverge, so that the stigmas occupy the position taken up by the anthers in the first (male) stage.

Kirchner says that the flowers vary in size without any other correlated differences.

VISITORS.—I have seen a hover-fly (Eristalis arbustorum *L.*), skg., and also a beetle (Meligethes) at Kiel. Sprengel describes pollination by the blow-fly Calliphora vomitoria *L.*

Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Coleoptera. (*a*) *Curculionidae*: 1. Miarus graminis *Schönh.* (*b*) *Dermestidae*: 2. Anthrenus scrophulariae *L.* (H. M.). **B. Diptera.** (*a*) *Empidae*: 3. Empis tessellata *F.*, skg. (H. M.). (*b*) *Syrphidae*: 4. Eristalis arbustorum *L.*, skg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 5. Andrena schrankella *Nyl.* ♂, skg. (H. M.); 6. Halictus malachurus *K.* ♀, skg. and po-cltg. (H. M.); 7. H. minutissimus *K.* ♀, do. (H. M.); 8. H. morio *L.* ♀, do. (H. M.); 9. H. nitidiusculus *K.* ♀, do. (H. M.). (*b*) *Tenthredinidae*: 10. Cephus sp. (H. M.).

MacLeod noticed 2 short-tongued bees and 4 Muscids in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 423–4).

964. S. tridactylites L. (Sprengel, 'Entd. Geh.,' pp. 244–6; Herm. Müller, 'Weit. Beob.,' I, p. 297.)—Sprengel says that the flower mechanism of this species agrees entirely with that of S. granulata. He also quotes the observation of Linnaeus, 'sub florescentia germen stylo stigmatibusque destitutum,' which cannot be interpreted otherwise than as meaning that the styles and stigmas do not mature until the anthers have withered.

Hermann Müller, on the other hand, describes the small white flowers as feebly protogynous. When they open the stigmas are already mature. Soon afterwards the anthers dehisce successively, first those of the outer whorl, then those of the inner. As this takes place they regularly come into contact with the stigmas, effecting automatic self-pollination at an early stage, and this is completely effective. In dull weather the flowers remain shut, or close if they had previously opened. During such weather the nectary, which surrounds the style as a yellow fleshy ring, does not secrete, but in the sunshine it produces glistening drops in the midday hours.

Kerner states that, besides hermaphrodite blossoms, there are pseudo-hermaphrodite pollen flowers and fruiting flowers on the same plant. Moreover, Warnstorf also says that the protogynous hermaphrodite flowers are associated on the same stock with pseudo-hermaphrodite ones of both kinds; sometimes the carpels aborting, sometimes the stamens.

965. S. tricuspidata Rottb. (Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 22–5.)—Warming states that the stellate flowers of this species are at first slightly protandrous in Greenland, soon becoming homogamous. Self-pollination is therefore always possible, though the probability of its occurrence varies in different cases. As ripe fruits have been observed, it must be effective. The nectar is exposed. Besides hermaphrodite flowers, Warming noticed purely female ones.

Abromeit describes two varieties of flower for Greenland; one with narrow white petals spotted with yellow and purple-red, the other with small petals of distinctly yellow colour ('Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 35–7).

966. S. flagellaris Willd. (Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 25–6.)—Of three plants of this species brought from Spitzbergen, Warming describes two as protogynous; in the third the outer anthers were applied to the stigmas in such a way that automatic self-pollination must have taken place. For Nova Zemlia, Ekstam describes the odourless flowers as slightly protandrous or homogamous, self-pollination being quite possible.

Andersson and Hesselman state that the species is in flower in Spitzbergen from the beginning of July till September; ripe fruits were observed August 20, 1897 ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 26–7). The bell-shaped, bright yellow flowers are 8·0–11·5 mm. long, and 9·5–13·0 mm. broad; there is a swelling on either side the base of each petal. In Van Meyen Bay the observers mentioned found the flowers to be protogynous at the beginning of anthesis, the anthers subsequently ripening and coming into contact with the stigmas. Ekstam, on the other hand, describes specimens from Advent Bay as homogamous.

967. S. Cotyledon L.—Briquet says that in this protandrous species the outer and inner stamens move in succession towards the middle of the flower ('Études de biol. flor. dans les Alpes occident.'). The diameter of the corolla may be as much as 15 mm. The exposed nectar is secreted by a green disk. Flies alighting upon the petals regularly effect cross-pollination. Kirchner points out that the flower mechanism was long ago described by Sprengel ('Entd. Geh.,' p. 246), and subsequently by Lindman ('Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.,' p. 60).

On the Dovrefjeld, according to Lindman, the flowers smell rather strongly of apples, and are markedly protandrous.

Visitors.—Lindman observed numerous flies and a humble-bee on the Dovrefjeld.

968. S. hypnoides L.—

Visitors.—In Dumfriesshire, an Empid and 3 Muscids have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 71).

969. S. cernua L. (Lindman, op. cit.; Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 3–6.)—The conspicuous flowers of this species, according to Lindman and Warming, are markedly protandrous as a rule on the Dovrefjeld, and also in Greenland, Nordland, Finmark, and Spitzbergen. Occasionally, however, they are protogynous, and this perhaps indicates a transition towards the production of female flowers. The nectar is exposed. The inadequate production of fruits is compensated for by the development of bulbils taking the place of flowers, both in northern regions, and also, according to Kerner, in the Tyrol.

Andersson and Hesselman state that the species flowers in Spitzbergen from the beginning of July to the beginning of August, here and there to the end of the latter month: in Beeren Island a stock with fully developed flower-buds ready to open was seen on June 18, 1898 ('Bidrag till Känned. om Spetsbergens o. Beeren Eil.

Kärlväxtflora,' pp. 28–9). A well-marked small-flowered female form, and a specimen with normal flowers, but only 56 % of functional pollen-grains, were also observed. Ekstam ('Blütenbiol. Beob. a. Spitzbergen') describes the flowers as possessing a strong and agreeable odour of almonds: diameter 14–16 mm. (in some cases 18–22 mm.). The colour is usually pure white, but the centre of the corolla is sometimes marked with red lines, and tinged with pink. Ekstam, confirming the observations of Warming, states that marked protandry obtains for Spitzbergen. Only the uppermost flower develops as a rule, the others being transformed into bulbils. The flowers are extremely sensitive to light, and assume a fixed light-position when the illumination is favourable. Ekstam did not find any ripe fruits in Spitzbergen.

Abromeit says that terminal flowers with small petals completely hidden in the calyx (var. *cryptopetala* K. Rosenvinge) were observed in Greenland ('Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 34).

For Nova Zemlia, Ekstam describes the flowers as conspicuous (diameter up to 20 mm.) and smelling slightly of almonds. They are usually protogynous-homogamous, sometimes protandrous-homogamous.

VISITORS.—On six days of July and August Ekstam saw small and medium-sized flies in Spitzbergen. He also noticed a medium-sized fly in Nova Zemlia.

970. S. nivalis L. (Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Warming, Bot. Tids., Kjöbenhavn, xvi, 1888, pp. 14–17.)—The flowers of this species are small and inconspicuous, the erect petals being little longer than the calyx. The nectar is half concealed. Warming says that protogyny is not well marked, while homogamy is not infrequent, and cultivated plants may even exhibit protandry. Lindman observed homogamy with a tendency to slight protandry on the Dovrefjeld. According to Warming, self-pollination is inevitable in protandrous plants; but this is less easily possible in the case of the Norwegian form, which possesses reflexed stamens. Both Lindman and Warming observed ripe fruits.

Ekstam says that the flowers are commonly protandrous in Nova Zemlia, though some are homogamous or slightly protogynous-homogamous. The diameter of the flowers in Arctic Siberia is 10 mm., according to Kjellman.

Andersson and Hesselman state that the species flowers in Spitzbergen from the beginning of July to the end of August or the beginning of September, and sets fruit every year ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 22). The flowers are 5·5–8 mm. in diameter, and white or bright greenish-yellow in colour, sometimes with a reddish spot near the tip of each petal. The stamens are orange-coloured, and the ovary greenish-yellow. The pollen-grains quickly swell up in distilled water. Ekstam found the flowers in Spitzbergen protogynous-homogamous, and noticeably fragrant. He states that the stigmas are situated at the same or a lower level than the anthers, which bend inwards when they dehisce, and autogamy is thus made possible ('Blütenbiol. Beob. a. Spitzbergen,' p. 11).

For the variety *β tenuis* Wahl., in Greenland, Abromeit gives the colour of the flowers as white or light purple, and that of the filaments as more or less purple ('Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 32).

VISITORS.—Ekstam saw a large and a small fly in Spitzbergen. He also noticed medium-sized flies in Nova Zemlia.

971. **S. juniperifolia** Adams. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, p. 326.)—Kerner says that geitonogamy takes place in this species, for though the direction of the styles and the position of the stigmas remain unchanged, the filaments elongate and curve in such a way that the pollen can reach the stigmas of neighbouring flowers.

972. **S. umbrosa** L. (Herm. Müller, 'Fertilisation,' p. 245.)—Hermann Müller says that, 'the prettily dotted petals of *S. rotundifolia* and *S. umbrosa* L., seem to be due to the influence of certain elegant and prettily coloured *Syrphidae*, by which they are especially visited and cross-fertilized.'

VISITORS.—Herm. Müller noticed the Syrphid Ascia podagrica *L.* Plateau observed a Muscid (Lucilia caesar *L.*), Syrphids (Melanostoma mellina *L.*, Helophilus pendulus *L.*, Syrphus corollae *F.*), and bees (Apis, Andrena nana *K.*, Megachile ericetorum *Lep.* (=M. fasciata *Sm.*), Odynerus quadratus *Pz.*(?)).

973. **S. crassifolia** L. (=Bergenia biflora *Moench*). (Herm. Müller, 'Fertilisation,' pp. 243, 247, 'Weit. Beob.,' I, p. 298.)—The flowers of this species are protogynous.

VISITORS.—Herm. Müller observed bees, skg. (Apis, Bombus hortorum *L.* ♀, B. pratorum *L.* ♀). Loew saw a humble-bee (B. terrester *L.* ♀), skg., in the Berlin Botanic Garden.

269. Bergenia Moench.

974. **B. subciliata** A. Br.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Hymenoptera. (*a*) *Apidae*: 1. Anthophora pilipes *F.* ♂, skg.; 2. Apis mellifica *L.* ☿, skg.; 3. Osmia rufa *L.*, skg. (*b*) *Vespidae*: 4. Odynerus parietum *L.* ♀ and ♂. **B. Lepidoptera.** *Rhopalocera*: 5. Colias rhamni *L.*, skg.

270. Chrysosplenium Tourn.

Flowers inconspicuous, golden-yellow, or greenish in colour; homogamous, protogynous, or slightly protandrous. The nectar is exposed, and secreted by a disk surrounding the styles. The foliage-leaves around the flowers are mostly streaked with golden-yellow, and increase conspicuousness. Besides hermaphrodite flowers, there are often some purely male ones as well.

975. **C. alternifolium** L. (Sprengel, 'Entd. Geh.,' p. 241; Ricca, Atti Soc. ital. sc. nat., Milano, xiii, 1870, p. 257; Herm. Müller, 'Fertilisation,' pp. 245–6; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 290–1; Kirchner, 'Flora v. Stuttgart,' p. 406; Warming, 'Arkt. Växt. Biol.,' p. 7; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 379; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller describes the inconspicuous yellow flowers of this species as homogamous, but Ricca says they are slightly protogynous, with persistent stigmas. Ekstam, for Nova Zemlia, speaks

of them as protogynous-homogamous. I found only homogamous flowers in the neighbourhood of Kiel. Each blossom is in the form of a shallow cup, 5–7 mm. in diameter; from the middle of this the two projecting styles (about 1 mm. long) project and curve outwards. They carry the somewhat thickened smooth stigmas at their tips, and are surrounded at the base by a broad, fleshy, yellowish disk, on which numerous drops of nectar spread out to form a thin layer. The eight stamens are erect; the anthers rise about 1 mm. above the disk, and are at the same level as the stigmas, which remain receptive throughout anthesis. The anthers dehisce in succession and get covered with pollen all round. As there are no petals, and the four sepals spread out flat, the 6–12 or more flowers that are usually crowded together into a cyme make up a practically level surface, which is extended by the uppermost golden-yellow foliage leaves, so that there is a considerable area by which numerous small short-tongued insects are attracted. As these visitors usually touch one or several stamens with one side of their bodies, and the stigmas with the other side, they commonly effect cross-pollination, but owing to the erratic way in which they creep about the flowers and inflorescences, self-pollination is also a frequent occurrence. It can only take place automatically when in exceptional cases the flowers are nearly or quite vertical, so that pollen can fall upon the stigmas. Kerner says that at a later stage the peduncles curve downwards, so that the flowers come to be inclined or pendulous, and the stigmas being brought into the line of fall of the pollen autogamy necessarily follows.

FIG. 132. *Chrysosplenium alternifolium*, *L.* (after E. Warming). Longitudinal section through a flower (× 8).

Lindman found the flowers to be homogamous on the Dovrefjeld, but owing to the distance between anthers and stigmas automatic self-pollination is here scarcely possible. The flowers observed were larger (7 mm. diameter) than those from the neighbourhood of Stockholm.

Andersson and Hesselman state that the var. *tetrandrum* Lund flowers in Spitzbergen from the end of June till at least the end of August, when ripe fruits were also observed ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxt-flora,' p. 31).

Hermann Müller calls attention to the fact that the pollination of this plant is also occasionally due to snails. He found small snails (young Succinea) on many flowers, sometimes creeping about, sometimes devouring the styles or one or several stamens. He could generally see a number of pollen-grains in the slimy trail left on the flowers by these guests, and in several cases noticed the direct transfer to the stigmas. I can partly confirm these observations, for though I have not actually seen the snails at work, I have often noticed little slimy trails among the flowers, obviously made by them, and have also frequently remarked the results of their activity, in the form of gnawed edges and surfaces of the foliage-leaves and flowers. Besides this, I have observed many ants and minute Muscids licking nectar, but did not collect them and determine their species.

VISITORS.—Herm. Müller observed the following, all nect-lkg.—

A. Coleoptera. (*a*) *Colydiidae*: 1. Corticaria gibbosa *Hbst.* (*b*) *Curculionidae*: 2. Apion onopordi *K.*; 3. A. varipes *Germ.* (*c*) *Phalacridae*: 4. Olibrus aeneus *F.* **B. Diptera.** (*a*) *Cecidomyidae*: 5. 6 individuals. (*b*) *Chironomidae*: 6. 3 individuals, belonging to minute species. (*c*) *Muscidae*: 7. Sciomyza cinerella *Fall.* (*d*) *Mycetophilidae*: 8. 5 individuals. (*e*) *Simuliidae*: 9. Simulia sp. **C. Hymenoptera.** (*a*) *Cynipidae*: 10. Eucoila *Westw.* sp. (*b*) *Formicidae*: 11. Lasius niger *L.* ☿; 12. Myrmica levinodis *Nyl.* ☿; 13. M. ruginodis *Nyl.* ☿.

Herm. Müller saw 12 Diptera, an ant, 2 Ichneumonids, and a beetle in the Alps ('Alpenblumen,' p. 89).

Alfken noticed 2 bees (Andrena gwynana *K.* ♀ and ♂, skg., and A. parvula *K.* ♀ and ♂, do.) at Bremen. MacLeod observed 2 moths, 3 short-tongued Hymenoptera, 3 beetles, and a Neuropterid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 291).

Burkill records the following for the coast of Yorkshire, all skg. ('Fertlsn. of Spring Fls.').—

A. Coleoptera. 1. Lathrimaeum atrocephalum *Gyll.*; 2. Tachyporus chrysomelinus *L.* **B. Diptera.** *Muscidae*: 3. Cecidomyia sp. and 3 other small flies. **C. Hemiptera.** 4. One sp.

976. C. oppositifolium L. (Herm. Müller, 'Fertilisation,' p. 247, 'Weit. Beob.,' I, p. 298.)—Hermann Müller states that the hermaphrodite flowers of this species are protogynous with persistent stigmas. In other respects their mechanism agrees with that of C. alternifolium, though they and the bracts surrounding them are smaller and less conspicuously coloured, besides which automatic self-pollination is easy. Kobus describes the species as andromonoecious, developing numerous purely male flowers when it grows in thick clumps (D. bot. Monatsschr., Arnstadt, i, 1883, p. 74).

Burkill ('Fertlsn. of Spring Fls.') remarks that the species is gynodioecious on the Yorkshire coast, and that female plants are common throughout the whole district. They are readily recognized by their green flowers, for the golden-yellow colour of the hermaphrodite blossoms is almost entirely absent. Female flowers are also smaller than hermaphrodite ones. No trace of pollen is to be found in them: even anthers are almost completely absent, and any which may remain are functionless.

VISITORS.—Herm. Müller observed 2 beetles (Coccinella bipunctata *L.* and C. impustulata *L.*) and 2 flies (Chlorops scalaris *Mg.* and Musca domestica *L.*) seeking the drops of nectar which are distinctly visible.

Burkill observed the following on the Yorkshire coast.—

A. Araneida. 1. 1 sp., lying in wait. **B. Collembola.** 2. Lepidocyrtus sp. **C. Diptera.** (*a*) *Muscidae*: 3. Lonchoptera sp.; 4. Sepsis nigripes *Mg.* (*b*) *Mycetophilidae*: 5. Exechia sp.; 6. Sciara sp. (*c*) *Syrphidae*: 7. Melanostoma quadrimaculata *Verrall.* (*d*) *Tipulidae*: 8. Chironomus sp. **D. Hymenoptera.** *Ichneumonidae*: 9. One small sp. **E. Thysanoptera.** 10. Thrips sp.

In Dumfriesshire, an Ichneumonid, 3 Muscids, and a beetle have been recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 72).

977. C. tetrandrum Fries (= C. alternifolium, according to the *Index Kewensis*). (Warming, 'Arkt. Växt. Biol.,' pp. 4–7.)—Warming investigated plants from Spitzbergen. The flowers are greenish, less open than in C. oppositifolium, and with a scarcely developed nectary. Besides homogamy, slight protandry was observed. Automatic self-pollination regularly obtains by contact of the stigmas with the anthers of the two outer stamens. This must be effective, for almost every flower sets fruit.

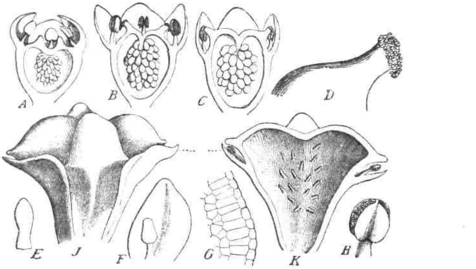


FIG. 133. *Chrysosplenium tetrandrum, Fries* (after E. Warming). *A*. Longitudinal section through an almost closed flower. Anthers unripe, styles short. *B*. Do. through a fully open young flower. The stigmas touch some of the ripe anthers, which deposit a quantity of pollen upon them (cf. *D*). *C*. A fertilized flower. The formation of seeds and setting of fruit have begun; the free parts are more erect, and have closed in somewhat. *D*. Style of *B* more highly magnified, showing the stigma covered with numerous pollen-grains. *E*, *F*. Sterile stamens, the latter in connexion with its perianth leaf. *G*. Longitudinal section through a sterile stamen. *H*. Normal anther. *J*. Scarcely ripe fruit. *K*. Do. through a similar fruit; the seeds have been removed, but some of the funicles are still present in part. (*A*, *B*, *C*, *J*, *K* × 8.)

271. Heuchera L.

978. H. cylindracea Lindl.—

VISITORS.—Loew observed 2 bees in the Berlin Botanic Garden (Apis mellifica *L*. ☿, skg., and Halictus cylindricus *F*. ♀, do.).

272. Tellima R. Br.

979. T. grandiflora R. Br.—

VISITORS.—Loew observed a bee (Apis mellifica *L*. ☿) and a butterfly (Pieris brassicae *L*.), skg., in the Berlin Botanic Garden.

273. Tiarella L.

980. T. cordifolia L.—Francke describes this species as protogynous ('Inaug.-Dissert.,' Halle, 1883). The anthers ripen in succession at long intervals.

274. Parnassia L.

Flowers white in colour, markedly protandrous, with half-concealed nectar. There are five fringed glandular staminodes opposite the petals. Each of them swells into a disk, with two shallow depressions on the upper side, into which the tolerably exposed nectar is sparingly secreted.

981. P. palustris L. (Sprengel, 'Entd. Geh.,' pp. 166–73; C. W. Ritter, in Hoppe's 'Bot. Taschenbuch,' Regensburg, 1803, Nachschrift, p. 181; Delpino, 'Ult. Oss.,' p. 168; Herm. Müller, 'Fertilisation,' pp. 247–8, 'Alpenblumen,' pp. 111–13; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 209, 213, 249, 251, 307; Verhoeff, 'Bl. u. Insekt. d. Ins. Norderney'; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 34–5, 150, 'Blütenbiol. Notizen.')—This species bears protandrous deceptive flowers. Their mechanism was very fully described by Sprengel, but he remained in doubt as to whether they were day or night flowers. Since Sprengel's time this most interesting flower has been studied by Ritter, Hermann Müller, and others, and we are particularly indebted to Müller for an explanation of the significance of its individual parts. The five white petals are furrowed by colourless veins, and in front of them there are five characteristic yellow-green organs, the staminodes, each of which possesses a short broad stalk that expands into a disk bearing 7–13 or even as many as 25 stalked glands, serving to attract insects. Some nectar is secreted on either side the insertion of the stalk. When the flower opens the anthers are still

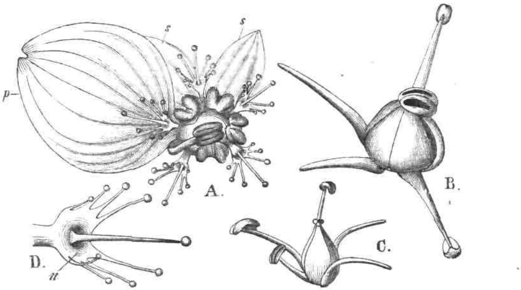


FIG. 134. *Parnassia palustris*, *L.* (after Herm. Müller). *A.* Flower after removal of three sepals and four petals, seen from above, immediately after opening. One stamen has lengthened, and its anther lies upon the middle of the pistil, the stigma being still immature. This stamen is beginning to dehisce, and to cover its upwardly directed outer surface with pollen. *B.* Flower after removal of calyx, corolla and staminodes. Four stamens have already shed their pollen and curved back; the fifth, which is covered above with pollen, lies upon the still immature pistil. *C.* The same flower in the second (female) stage. The stamens have all dehisced; the stigma, which is here represented as trilobed, but is usually four-lobed, is mature. *D.* Staminode, more highly magnified. *n*, nectar; *p*, petal; *s*, sepal.

unripe, their filaments are short, and they lie close to the conical pistil, the stigma of which is also still immature. The stamens now ripen successively, their filaments elongating to such an extent that the anthers lie exactly upon the top of the ovary, their dehisced pollen-covered surfaces facing upwards. After about a day an anther has shed its pollen and bends outwards, when another takes its place at the top of the pistil, and so on. At the end of four days, when all the anthers are empty, the apical stigma unfolds, occupying exactly the place taken up in the first (male) stage by a ripe anther.

The stalked glands of the staminodes attract insects by their glistening appearance, which apparently suggests the presence of abundant nectar. The more intelligent

insects, however, do not allow themselves to be deceived by this, but the stupider ones (flies and beetles) are repeatedly attracted, and effect cross-pollination as they seek out the scanty nectar. The smaller flies, however, usually go round and round the flower, licking the nectar without touching either pollen or stigma, and therefore render no service to the flower. But larger insects mostly settle upon the middle of the flower to suck, turning round from one nectary to another, so that in younger blossoms they cover their under-side with pollen, which they transfer to the stigmas of older ones[1].

The flowers are very small (25–13 mm. in diameter) in the Alps, and possess only three-lobed stigmas (cf. Fig. 134), though elsewhere there are four-lobed ones. In the Scandinavian highlands, according to Lindman, the flowers are also often very small, sometimes not more than 11 mm. in diameter. They are fragrant, smelling like honey.

During September, 1896, I made a noteworthy observation on flowers placed in water in a shady part of my room, and which kept fresh for a week. Under these circumstances the buds developed into purely homogamous flowers; all five stamens diverged and turned their dehisced anthers outwards. The stigmas matured simultaneously, so that, the flowers being obliquely placed, pollen could fall upon them, as actually happened in some cases. Flowers kept in a room, therefore, behaved quite differently from those in the open air, confirming in this case the advice of Sprengel ('Entd. Geh.,' p. 22) not to bring flowers from the garden or the fields, but rather to study them among their natural surroundings.

VISITORS.—Herm. Müller (H. M.) and myself (Kn.) have observed the following.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella conglobata *L.*, very common, nect-lkg. (H. M.); 2. C. septempunctata *L.*, do. (H. M., Kn.). **B. Diptera.** (*a*) *Muscidae*: 3. Aricia sp. (Kn.); 4. Lucilia caesar *L.* (Kn.); 5. Pollenia vespillo *F.*, skg. (H. M.); 6. Sarcophaga carnaria *L.* (H. M., Kn.); 7. Smaller Muscidae (H. M.). (*b*) *Syrphidae*: all skg.: 8. Eristalis arbustorum *L.* (H. M., Kn.); 9. E. nemorum *L.* (H. M., Kn.); 10. E. pertinax *L.* (Kn.); 11. E. tenax *L.* (Kn.); 12. Helophilus floreus *L.*, freq. (H. M.); 13. H. pendulus *L.*, especially freq. (Kn.); 14. Melanostoma mellina *L.* (H. M., Kn.); 15. Melithreptus menthastri *L.* (H. M.); 16. M. scriptus *L.* (H. M.); 17. M. taeniatus *Mg.* (H. M., Kn.); 18. Syritta pipiens *L.*, freq. (H. M., Kn.); 19. Syrphus balteatus *Deg.*, very common, now and then po-dvg. (H. M., Kn.); 20. S. excisus *Zett.* (H. M.); 21. S. pyrastri *L.*, freq. (H. M., Kn.); 22. S. ribesii *L.*, do. (H. M., Kn.). (*c*) *Tipulidae*: 23. Tipula oleracea *L.* (H. M.). **C. Hymenoptera.** (*a*) *Formicidae*: 24. Formica sp. (Kn.). (*b*) *Ichneumonidae*: 25. Numerous small species, skg. (H. M.). (*c*) *Sphegidae*: 26. Gorytes campestris *Müll.* (H. M.); 27. Pompilius viaticus *L.* (H. M.). (*d*) *Tenthredinidae*: 28. Tenthredo sp., skg. (H. M.).

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[1] In my work, 'Blumen und Insekten auf den nordfriesischen Inseln' (1892, pp. 34–5), I have pointed out that the term 'deceptive flower' is not strictly applicable to Parnassia, which secretes at least as much nectar as most Umbelliferae. Though fairly abundant it does not taste sweet to us. That it is, however, palatable to insects attracted by the pronounced honey-odour of the flower, is shown by the zeal with which these visitors seek it out; and, besides, the numerous lacerations of the 'nectar apparatus' indicate that boring and sucking take place. Professor Ludwig of Greiz has told me in a letter that he shares my opinion, adding that he could not understand why the blossoms have been described as 'deceptive flowers.'

Alfken (A.) and Leege (L.) record the following for Juist.—

A. Coleoptera. *Telephoridae*: 1. Cantharis fulva *Scop.*, freq. (A., L.). **B. Diptera.** (*a*) *Dolichopodidae*: 2. Dolichopus plumipes *Scop.* (L.). (*b*) *Muscidae*: 3. Cynomyia mortuorum *L.* (A.); 4. Lucilia caesar *L.* (A.); 5. Spilogaster quadrum *F.*, freq. (A.); 6. S. sp. (A.). (*c*) *Stratiomyidae*: 7. Nemotelus notatus *Zett.*, freq., po-dvg. and skg. (A.); 8. Odontomyia viridula *F.*, one (A.). (*d*) *Syrphidae*: 9. Eristalis arbustorum *L.* (A.); 10. Melithreptus strigatus *Staeg.* ♀ and ♂, freq. (A.); 11. Platycheirus sp. (A.); 12. Syrphus balteatus *Deg.*, freq. (A.); 13. S. trilineatus *L.*, rare (A.). **C. Hymenoptera.** (*a*) *Formicidae*: 14. Lasius niger *L.* (A.). (*b*) *Ichneumonidae*: 15. Glypta fronticornis *Gr.* (L.); 16. Lissonota commixta *Hgr.* (L.). (*c*) *Scoliidae*: 17. Tiphia femorata *F.* ♀, one (A.). **D. Lepidoptera.** (*a*) *Satyridae*: 18. Hipparchia semele *L.*, very common, skg. (A.). (*b*) *Noctuidae*: 19. Plusia gamma *L.*, freq., skg.

Verhoeff saw the following in Norderney.—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *L.*, one. **B. Diptera.** *Bibionidae*: 2. Dilophus vulgaris *Mg.*, very common.

Lindman observed numerous flies, a beetle, and a Lepidopterid on the Dovrefjeld. Herm. Müller saw 43 species of flies, 2 beetles, 8 Hymenoptera, and 6 Lepidoptera in the Alps. MacLeod noticed an Ichneumonid, a Lepidopterid, a hover-fly, and 7 Muscids in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 424–5). Delpino saw a hover-fly, Helophilus floreus *L.*, at Florence.

Burkill observed the following on the East coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes picipes *Sturm.*, skg. **B. Diptera.** (*a*) *Bibionidae*: 2. Scatopse brevicornis *Mg.* (*b*) *Muscidae*: 3. Anthomyia brevicornis *Zett.*, po-dvg.; 4. A. radicum *L.*, freq., skg.; 5. Calliphora erythrocephala *Mg.*, skg.; 6. Coelopa sp., po-dvg.; 7. Hydrellia griseola *Fall.*; 8. Phytomyza sp.; 9. Sarcophaga sp.; 10. Sepsis cynipsea *L.* (*c*) *Phoridae*: 11. Phora sp. (*d*) *Syrphidae*: 12. Eristalis tenax *L.*; 13. Helophilus pendulus *L.*, skg.; 14. Melanostoma mellina *L.*; 15. Platycheirus albimanus *F.*; 16. Sphaerophoria scripta *L.*, skg. (*e*) *Mycetophilidae*: 17. Sciara sp. **C. Hemiptera.** 18. One sp. **D. Hymenoptera.** (*a*) *Formicidae*: 19. Formica fusca *L.*, skg.; 20. Myrmica rubra *L.*, skg. (*b*) *Ichneumonidae*: 21. 3 species.

275. Philadelphus L.

Large, white, very fragrant flowers; with half-concealed nectar, secreted by a disk on the inferior ovary.

982. P. coronarius L. (Sprengel, 'Entd. Geh.,' p. 267; Herm. Müller, 'Fertilisation,' pp. 248–9, 'Weit. Beob.,' II, pp. 237–8; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Blumenbiol. Beob. a. d. Ins. Rügen.')—In this species, according to Hermann Müller, the stigmas are mature when the flower opens, so that crossing is necessarily effected by insect visitors which have previously been dusted with pollen. After a time the anthers dehisce, those of the outer stamens doing so first. As the numerous anthers are very close to the stigmas, which are situated in the line of fall of the pollen, automatic self-pollination readily takes place should insect-visits fail. If a flower is not visited till the anthers have dehisced, self- and cross-pollination are both possible. Warnstorf describes the normal pollen-grains as yellow, ellipsoidal, closely tuberculated, about 25 μ long and 12–13 μ broad. They are mixed with much smaller, apparently abortive grains.

The large white flowers attract numerous insects owing to their conspicuousness and pronounced fragrance.

VISITORS.—MacLeod saw 2 Noctuids in Belgium. Herm. Müller (H. M.) chiefly records bees, while in Schleswig-Holstein and Rügen I myself (Kn.) observed Diptera for the most part. Our joint list is as follows.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus pimpinellae *F.* (H. M.); 2. A. scrophulariae *L.* (H. M.). (*b*) *Mordellidae*: 3. Mordella aculeata *L.* (H. M.). (*c*) *Nitidulidae*: 4. Meligethes, po-dvg. (Kn., H. M.). (*d*) *Scarabaeidae*: 5. Phyllopertha horticola *L.*, gnawing the flowers (H. M.). (*e*) *Telephoridae*: 6. Dasytes, freq. (H. M.); 7. Malachius bipustulatus *L.*, dvg. the anthers (H. M.). **B. Diptera.** (*a*) *Muscidae*: 8. Sepsis sp. (H. M.). (*b*) *Syrphidae*: 9. Ascia podagrica *F.*, freq., skg. and po-dvg. (H. M.); 10. Eristalis arbustorum *L.*, po-dvg. (Kn.); 11. E. pertinax *Scop.*, do. (Kn.); 12. E. tenax *L.*, do. (Kn.); 13. Helophilus floreus *L.*, do. (H. M.); 14. Rhingia rostrata *L.*, skg. (Kn., H. M.); 15. Syritta pipiens *L.*, po-dvg. (Kn., H. M.); 16. Syrphus ribesii *L.*, skg. and po-dvg. (Kn., H. M.); 17. Volucella bombylans *L.*, po-dvg. (Kn., H. M.); 18. V. pellucens *L.* ♀, do. (Kn.). **C. Hymenoptera.** (*a*) *Apidae*: 19. Andrena albicans *Müll.* ♂ and ♀, very numerous, skg. and po-cltg. (H. M.); 20. A. dorsata *K.* ♀, po-cltg. (H. M.); 21. A. fasciata *Wesm.* ♀, do. (H. M.); 22. A. fulvicrus *K.* ♀, do. (H. M.); 23. A. nitida *Fourcr.* ♀, do. (H. M.); 24. A. tibialis *K.* ♀, skg. (H. M.); 25. A. trimmerana *K.* ♀, skg. and po-cltg. (H. M.); 26. Apis mellifica *L.* ☿, freq., skg. and po-cltg. (Kn., H. M.); 27. Bombus agrorum *F.* (Kn.), skg. for a short time (H. M.); 28. B. lapidarius *L.* ☿, skg. (Kn.); 29. B. pratorum *L.* ☿, skg. and po-cltg. (H. M.); 30. Halictus leucozonius *Schr.* ♀, po-cltg. (H. M.); 31. H. sexnotatus *K.* ♀, do. (H. M.); 32. Osmia rufa *L.* ♀, freq., po-cltg. (H. M.); 33. Prosopis armillata *Nyl.* ♂, po-dvg. (H. M.); 34. Psithyrus barbutellus *K.* ♀, skg. (*b*) *Formicidae*: 35. Lasius niger *L.* ☿, skg. (H. M.). **D. Lepidoptera.** *Rhopalocera*: 36. Pieris brassicae *L.*, skg. (H. M.); 37. P. napi *L.*, do. (H. M.); 38. P. rapae *L.*, do. (Kn.).

Cobelli gives 9 Hymenoptera not observed by Herm. Müller (Nuovo Giorn. bot. ital., Firenze, xxv, 1893).

276. Deutzia Thunb.

983. D. crenata Sieb. et Zucc.—

VISITORS.—I observed 3 bees, skg., in the island of Rügen.—1. Apis mellifica *L.* ☿; 2. Bombus terrester *L.* ♀; 3. B. lapidarius *L.* ☿.

Alfken noticed the bee Andrena nigroaenea *K.* ♀ and ♂, skg., at Bremen.

277. Ribes L.

Flowers mostly greenish-yellow in colour, more rarely red or yellow; frequently associated in many-blossomed racemes. The nectar is free or concealed, and secreted by an epigynous disk. It may be so deeply placed (R. aureum) as to be accessible only to long-tongued bees. Sometimes the flowers are gynodioecious.

Hermann Müller ('Weit. Beob.,' I, pp. 298–300) gives the following oecological series of our wild and cultivated species of Ribes.—R. alpinum is the least specialized, its nectar being secreted in a shallow receptacular depression, and accessible to the shortest-tongued insects. In R. rubrum the depression is much deeper, and its bottom is covered with nectar. In shape it is approximately hemispherical, but its outer part is expanded. The downwardly directed bells of the gooseberry (R. Grossularia), though hardly deeper than those of R. rubrum, are somewhat

narrowed near the mouth by stiff hairs projecting from the edge of the receptacle and from the style, constituting a grating-like floor to the bell. The flowers are also rendered more difficult of access to flies, and better adapted to bees by being pendulous. The bells of R. nigrum are yet deeper, being almost spherical. They too are pendulous, and are still better adapted to bees than those of the last species. The flowers of R. sanguineum are tubular, though scarcely deeper than those of R. nigrum (3 mm.). But owing to the erect position of the petals, the tube is considerably prolonged (to more than 5 mm.). In spite of the tolerably erect position of the flowers, they are usually visited only by bees. The last term of the series is constituted by the flowers of R. aureum, which are in the form of long tubes (10–11 mm.). These are further prolonged some 3 mm. by the erect petals, so that the nectar is only accessible to very long-tongued bees. Cross-pollination by insects is secured by dioecism in the flowers of R. alpinum, but in all the other species by the relative positions of stamens and stigmas, which are successively touched by different sides of insect visitors. Since the hermaphrodite species are homogamous, the possibility of automatic self-pollination is not excluded in them.

984. R. alpinum L. (Herm. Müller, 'Fertilisation,' p. 249.)—The flowers of this species belong to class **E**. The greenish-yellow flowers are rendered con-

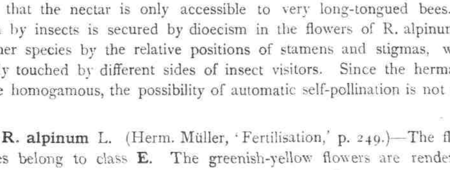


FIG. 135. *Ribes alpinum, L.* (after Herm. Müller). (1) Female flower seen from above. (2) The same in longitudinal section, seen from the side. (3) Do. of male flower. *a*, anthers; *a'*, vestigial anthers; *n*, nectary; *p*, petal; *s*, sepal; *st*, stigma; *st'*, vestigial stigma.

spicuous by the sepals, under which the minute petals are almost completely hidden. Hermann Müller describes the free upper part of the receptacle as forming a slightly concave depression, in which nectar is secreted. The species is dioecious, the male flowers being a little larger than the female ones, and of a yellowish-green colour. They are therefore more conspicuous than the greener female flowers, and consequently receive earlier visits. The female flowers possess vestigial stamens, and the male ones a vestigial pistil.

VISITORS.—Herm. Müller observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Scatophaga merdaria *F.*; 2. S. stercoraria *L.* (*b*) *Syrphidae*: 3. Syritta pipiens *L.*, all three freq., skg. **B. Hymenoptera.** *Apidae*: 4. Andrena albicans *Müll.* ♀ and ♂, very freq., skg. and po-dvg.; 5. A. gwynana *K.* ♂, skg.; 6. A. parvula *K.* ♂, do.; 7. Halictus nitidus *Schenck* ♂, do.; 8. H. nitidiusculus *K.* ♀, po-cltg.; 9. Sphecodes gibbus *L.* ♀, skg.

985. R. nigrum L. (Herm. Müller, 'Fertilisation,' p. 250; MacLeod, 'Nouv. recherches sur la fertlsn. de quelques pl. phanérog.')—The flowers of this species belong to class **C**. They possess a characteristic odour, and Hermann Müller

describes them as homogamous. The tips of the sepals are of a reddish colour, and the small petals are whitish. The latter incline together above, bringing the introrse anthers so close to the stigma that an insect probing for the nectar secreted in the base of the flower must touch one or two of the ripe anthers with one side of its head and the stigma, which projects somewhat beyond the anthers, with the other side. Cross-pollination necessarily follows. There are, however, but very few insect visitors, and it is usual for automatic self-pollination to take place, the pollen falling from the anthers upon the reflexed margin of the stigma.

VISITORS.—Herm. Müller saw Apis mellifica *L.* ☿ visiting the campanulate flowers (5 mm. deep). MacLeod made the same observation in Belgium. The latter also noticed that the honey-bee extracts nectar not only from open blossoms, but also opens the older buds with its jaws, and during this process dusts the already mature stigma with pollen brought from other flowers. MacLeod further observed ants, which use a lower flower as a ladder in their attempts to reach the nectar, from which the pendulous character of the flowers and the reflexed sepals keep them away. From below they licked the stigmatic secretion, but were unable to penetrate into the base of the flower. Plateau (Belgium) saw Bombus terrester *L.* Schenck (Nassau) observed Bombus hypnorum *L.* ♀ and B. pratorum *L.* ♀.

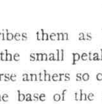


FIG. 136. *Ribes nigrum, L.* (after Herm. Müller). Flower seen from the side. *a*, anther; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

986. R. rubrum L. (Herm. Müller, 'Fertilisation,' p. 250.)—The flowers of this species belong to class **C.** They are greenish-yellow in colour, and Hermann Müller describes them as homogamous. The bells are tolerably flat, and widely open, so that the nectar is easily accessible. As in R. nigrum, insect visitors usually effect crossing. Automatic self-pollination is only possible for flowers that hang obliquely, in which case pollen falls from the stamens upon the underlying stigma.

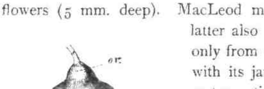


FIG. 137. *Ribes rubrum, L.* (from nature). *A.* Flower in section. *B.* Flower seen from above. *a*, anthers; *ca*, calyx; *co*, corolla; *s*, stigma.

VISITORS.—Herm. Müller observed the following.—

A. Hymenoptera. (*a*) *Apidae*: 1. Andrena fulva *Schr.* ♀, freq., skg. and po-cltg.; 2. A. parvula *K.* ♂, skg.; 3. A. smithella *K.* ♂, do.; 4. Apis mellifica *L.* ☿, freq., skg. and po-cltg. (*b*) *Tenthredinidae*. 5. Pteronus hortensis *Htg.*, skg.

Alfken saw 2 bees at Bremen, both skg.—1. Apis mellifica *L.* ☿; 2. Nomada borealis *Zett.* ♂.

The following were observed by the authorities, and at the places stated.—

Loew (Brandenburg) the hover-fly Syrphus lunulatus *Mg.* ('Beiträge,' p. 37). F. F. Kohl (Tyrol) the ruby-wasps Chrysis austriaca *F.* and C. fulgida *L.*, and the true wasp Odynerus trifasciatus *F.* Plateau (Belgium) Apis.

987. R. aureum Pursh. (Herm. Müller, 'Fertilisation,' p. 251, 'Weit. Beob.,' I, p. 301; Knuth, 'Bloemenbiol. Bijdragen'; Warnstorf, Verh. bot. Ver., Berlin,

xxxviii, 1896.)—In this species the free part of the receptacle is 10–11 mm. long, forming a tube which is prolonged another 3 mm. by the erect petals. The nectar is therefore only accessible to long-tongued bees, and the flowers belong to class **Hh.** In other respects their mechanism agrees with that of R. rubrum. Warnstorf describes them as protogynous: the stigma matures in the bud, and is very sticky. The style projects beyond the stamens, so that autogamy is prevented. The pollen-grains are white, irregularly roundish-tetrahedral, up to 41 μ in diameter.

The flowers are at first bright yellow, but become carmine-red in colour when the style and anthers have withered. Delpino was the first to attempt an explanation of this colour-change: he thinks that it enables insect visitors to recognize flowers which are over, thus being spared fruitless efforts to get nectar. Hermann Müller justly objects to this explanation on the ground that, if it were correct, flowers exhibiting colour-change would have no advantage over those which wither or fall off immediately anthesis is over. The persistence and brighter colouring of flowers that are over are better explained as serving primarily to enhance the conspicuousness of the inflorescences as a whole, so that insects are attracted in greater numbers, though the fact that flowers which have completed anthesis are readily recognized as such gives maximum value to the adaptation.

Visitors.—Herm. Müller saw Anthophora pilipes *F.*, skg., easily inserting its proboscis (20 mm. long) into the base of the flower. Delpino records the same bee for Italy, and I have noticed it in the Kiel Botanic Garden. Warnstorf also observed bees.

Alfken gives the following for Bremen.—

Hymenoptera. *Apidae*: 1. Andrena apicata *Sm.* ♀; 2. A. nigroaenea *K.* ♂; 3. A. varians *K.* ♂; 4. Nomada borealis *Zett.* ♂; 5. Osmia rufa *L.* ♀. **B. Diptera.** *Muscidae*: 6. Cynomyia mortuorum *L.*

Gerstäcker noticed the bee Osmia aurulenta *Pz.* ♂, freq., at Berlin.

988. R. sanguineum Pursh. (Herm. Müller, 'Fertilisation,' p. 251, 'Weit. Beob.,' I, p. 300.)—The flowers of this species belong to class **Hb.** Hermann Müller describes the free part of the receptacle as a tube 3 mm. long, prolonged to more than 5 mm. by the erect petals. Otherwise, the flower mechanism agrees with that of R. rubrum. Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896) says that there is slight protogyny. The style with its yellow very sticky stigma projects about 1 mm. beyond the stamens. The pollen-grains are white, rounded three- to five-sided, or shaped like an obelisk, smooth, with distinctly projecting germinating papillae, 37 μ in diameter on an average. The petals are at first quite white, but after fertilization they become rose-red in colour, so that, as in R. aureum, the inflorescence is rendered more conspicuous.

Visitors.—Herm. Müller observed 3 bees, skg.—1. Apis mellifica *L.* ☿; 2. Bombus pratorum *L.* ☿; 3. Osmia rufa *L.* ♀.

Plateau noticed Apis and Osmia bicornis *L.* in Belgium. Burkill saw Bombus terrester *L.* on the coast of Yorkshire ('Fertlsn. of Spring Fls.').

989. R. petraeum Wulf. (Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Herm. Müller, 'Fertilisation,' p. 251, 'Alpenblumen,' pp. 111–12.)—The flowers of this species belong to class **C.** Ricca describes them as slightly protogynous,

Hermann Müller as homogamous. As in the other species, cross-fertilization is favoured when insects visit the flowers, but automatic self-pollination readily takes place should they fail to do so.

VISITORS.—Herm. Müller noticed 2 hover-flies.

990. R. niveum DC. (Loew, 'Blütenbiol. Beiträge,' I, pp. 11–14.)—Loew observed that the bees which visit the protandrous flowers of this species insert their proboscis just above the petals into the slit between the bases of the filaments, thus pressing the anthers against the under-side of their body. When visiting a flower in the second (female) stage, pollen is necessarily deposited on the receptive stigmas.

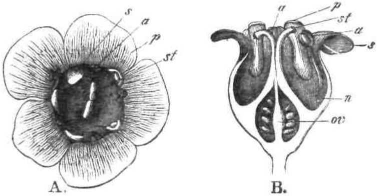


FIG. 138. *Ribes petraeum, Wulf.* (after Herm. Müller). *A.* Flower from above (× 7). *B.* The same in longitudinal section. *a*, anther; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

VISITORS.—Loew observed a bee (Anthophora pilipes *F.*) and a humble-bee (Bombus agrorum *F.*) in the Berlin Botanic Garden.

991. R. Grossularia L. (Herm. Müller, 'Fertilisation,' 250–1, 'Weit. Beob.,' I, p. 300; Kirchner, 'Flora v. Stuttgart,' p. 409; Knuth, 'Bloemenbiol. Bijdragen.')—The flowers of this species belong to class **C.** The anthers dehisce as they open,

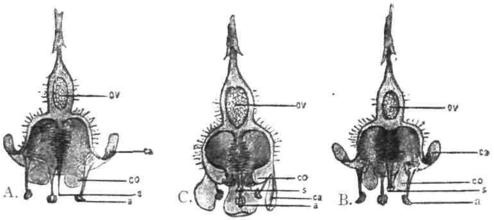


FIG. 139. *Ribes Grossularia, L.* (from nature). *A.* Flower in the first (male) stage: the anthers have dehisced, the stigma is still immature. *B.* Flower in the second (hermaphrodite) stage; the stigma is now mature. *C.* Flower after fertilization: the sepals have curved inwards. *a*, anther; *ca*, calyx; *co*, corolla; *ov*, ovary; *s*, stigma.

but the styles are not yet of full length, nor are the stigmas receptive (Hermann Müller). The reflexed sepals of these protandrous flowers are green, usually with reddish tips, while the petals, which are directed vertically downwards, are white. Nectar is secreted in the base of the bell-shaped extension of the receptacle, and the access to the secretion is narrowed by contraction of the receptacular margin,

and blocked by stiff hairs projecting perpendicularly from the style. The anthers at first project somewhat beyond the stigmas, but ultimately stand at the same level, so that automatic self-pollination must take place in horizontal or oblique flowers, though cross-pollination is favoured during insect-visits. After fertilization, the sepals curve upwards.

Besides hermaphrodite flowers, Kirchner noticed shrubs bearing female ones. The stamens of these are so short that their anthers (which do not dehisce) are at the level of the petals, or may even be situated more deeply in the receptacle.

VISITORS. — Herm. Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Calliphora erythrocephala *Mg.*, skg. (H. M.): 2. Sarcophaga carnaria *L.*, do. (Kn.); 3. Scatophaga stercoraria *L.*, do. (H. M.). (*b*) *Syrphidae*: 4. Eristalis aeneus *L.*, skg. and po-dvg. (H. M.); 5. E. tenax *L.*, do. (H. M., Kn.); 6. Syrphus ribesii *L.*, po-dvg. (Kn.). **B. Hymenoptera.** *Apidae*: 7. Andrena albicans *Müll.* ♂ and ♀, skg. and po-dvg. (H. M., Budd.); 8. A. fasciata *Wesm.* ♂, skg. (Budd.); 9. A. fulva *Schr.* ♀, skg. and po-dvg. (H. M., Budd.); 10. A. gwynana *K.* ♂ and ♀ (H. M.); 11. A. nigroaenea *K.* ♂, skg. (Budd.); 12. A. nitida *Fourc.* ♂, do. (H. M.); 13. A. parvula *K.* ♀, po-cltg. (Budd., Kn.); 14. A. smithella *K.* ♀, skg. (Budd.); 15. Apis mellifica *L.* ☿, do. (H. M., Kn.); 16. Bombus pratorum *L.* ♀ (H. M.); 17. B. scrimshiranus *K.* ♀ (H. M.); 18. B. terrester *L.* ♀ and ☿, skg. (H. M., Kn.); 19. Halictus cylindricus *K.* ♀, po-cltg. (Budd.); 20. H. rubicundus *Chr.* ♀, skg. (H. M.).

Wüstnei saw the bee Halictus flavipes *F.* ♀ in the island of Alsen.

Alfken and Höppner (H.) record the following for Bremen.—

A. Diptera. *Syrphidae*: 1. Eristalis pertinax *Scop.*; 2. Helophilus pendulus *L.*; 3. Syrphus ribesii *L.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Andrena albicans *Müll.* ♂, skg.; 5. A. propinqua *Schenck* ♀, do.; 6. A. trimmerana *K.* ♂, do.; 7. A. varians *K.* ♀ and ♂, do.; 8. Apis mellifica *L.*, do.; 9. Bombus agrorum *F.* ♀, do.; 10. B. derhamellus *K.* ♀ (H.); 11. B. jonellus *K.* ♀, skg.; 12. B. lapidarius *L.* ♀, po-cltg. (H.); 13. B. lucorum *L.* ♀, skg.; 14. B. pratorum *L.* ♀, do.; 15. B. sylvarum *L.* ♀ (H.); 16. B. terrester *L.* ♀, skg.; 17. Halictus calceatus *Scop.* ♀ (H.); 18. Nomada alternata *K.* ♀ and ♂; 19. N. bifida *Ths.* ♀ and ♂; 20. N. ruficornis *L.* ♀ and ♂; 21. N. succincta *Pz.* ♀ and ♂, skg.; 22. N. xanthosticta *K.* ♀ and ♂; 23. Osmia rufa *L.* ♂ and ♀. (*b*) *Tenthredinidae*: 24. Pteronus ribesii *Scop.* (*c*) *Vespidae*: 25. Odynerus callosus *Ths.* ♀.

Friese observed the following bees in Mecklenburg and Baden.—

1. Andrena carbonaria *L.*, not infrequent; 2. A. fulva *Schr.* (Baden), one individual; 3. A. nigroaenea *K.*, freq.; 4. A. tibialis *K.*, do.; 5. A. varians *K.*, with the vars. helvola *L.* and mixta *Schenck*, do.

Krieger saw the following bees at Leipzig.—

1. Andrena fulva *Schr.*; 2. A. nitida *Fourcr.*; 3. A. tibialis *K.*; 4. A. trimmerana *K.*; 5. A. varians *K.*; 6. Bombus hypnorum *L.* ♀; 7. B. lapidarius *L.* ♀; 8. B. pratorum *L.* ♀; 9. B. terrester *L.* ♀; 10. Nomada alternata *K.* = N. marshamella *K.*; 11. N. lineola *Pz.*; 12. Osmia rufa *L.*

Schmiedeknecht gives the following bees for Thuringia.—

1. Andrena albicans *Müll.*; 2. A. fulva *Schr.*; 3. A. propinqua *Schenck*; 4. A. trimmerana *K.* ♀ and ♂; 5. A. varians *K.* ♀ and ♂; 6. Bombus hypnorum *L.* ♀; 7. B. pratorum *L.* ♀; 8. B. terrester *L.* ♀; 9. Nomada fabriciana *L.*; 10. N. ochrostoma *K.*, var. hillana *K.*; 11. N. ruficornis *L.*, var. flava *Pz.*

Schenck records the following **Hymenoptera** for Nassau.—

(*a*) *Apidae*: 1. Andrena albicans *Müll.*; 2. A. cineraria *L.*; 3. A. combinata *Chr.*; 4. A. convexiuscula *K.*; 5. A. flavipes *Pz.*; 6. A. fulva *Schr.*; 7. A. gwynana *K.*; 8. A. nitida *Fourcr.*; 9. A. parvula *K.*; 10. A. propinqua *Schenck*; 11. A. tibialis *K.*; 12. A. trimmerana *K.*; 13. A. varians *K.*, with the var. helvola *L.*; 14. Bombus hypnorum *L.* ♀; 15. B. pratorum *L.* ♀; 16. B. terrester *L.* ♀; 17. Halictus albipes *F.*; 18. H. calceatus *Scop.*; 19. Nomada alternata *K.*; 20. N. ruficornis *L.*; N. flava *Pz.* ♂; 21. N. succincta *Pz.* (*b*) *Vespidae*: 22. Vespa germanica *F.* ♀, very common; 23. V. vulgaris *L.* ♀, freq.

Plateau noticed bees (Andrena sp., Apis, Bombus terrester *L.*, and Osmia bicornis *L.*) and a Muscid (Calliphora vomiteria *L.*) in Belgium.

Hoffer mentions Bombus terrester *L.* ♀ for Steiermark.

Von Dalla Torre and Schletterer give 2 bees for the Tyrol.—1. Andrena cineraria *L.*, rare; 2. A. tibialis *K.*

Burkill saw a wasp (Vespa sylvestris *Scop.*, skg.) and a Muscid (Scatophaga stercoraria *L.*, skg.) on the coast of Yorkshire.

E. D. Marquard observed the bee Andrena fulva *Schr.* in Cornwall.

XXXVI. ORDER *CRASSULACEAE* DC.

LITERATURE.—Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 73.

In this order the petals serve to attract insects, but some flowers are so small (Tillaea, Bulliarda) that they are only very occasionally visited. In the large-flowered species of Sempervivum and Sedum, on the other hand, self-pollination is often entirely excluded by marked protandry, and insects are absolutely necessary for fertilization. Protogyny is rarer. Nectar is usually secreted by glands at the base of the ovary. In our native species it is only slightly concealed, and most of the flowers must be referred to class **EC**. In some foreign species, however, it is very deeply situated.

278. **Tillaea** Mich.

992. **T. muscosa** L.—This species bears insignificant reddish or white flowers, solitary in the leaf-axils. They are apparently almost entirely dependent upon automatic self-pollination.

279. **Bulliarda** DC.

993. **B. aquatica** (= Tillaea aquatica *L.*, and T. prostrata *Schkuhr*).—According to Ascherson, the minute almost sessile white flowers of this species possess four nectaries, situated between the stamens and the ovary. In my herbarium specimens the pollen-covered anthers almost lie upon the stigmas.

280. **Rhodiola** L.

Flowers dioecious, or sometimes trioecious; with half-concealed nectar. The hermaphrodite flowers are protandrous.

994. **R. rosea** L. (= Sedum Rhodiola *L.*). (Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Schulz, 'Beiträge,' II, p. 188; Warming, Vet. Ak. Overs., Kjöbenhavn, 1886–7.)—The yellowish-red flowers of this species are dioecious in

the Riesengebirge, according to Schulz, and in the male and female flowers there are vestiges of the other sex-organs. Axell also found only dioecious plants, as did Lindman on the Dovrefjeld. Ricca, in the Alps, observed protandrous hermaphrodite flowers, and so did Warming in Greenland, but the latter noticed also cases of trioecism.

Ekstam says that in Nova Zemlia the flowers smell like honey, and secrete abundant nectar.

VISITORS.—Small flies were noticed by Ekstam in Nova Zemlia. Ricca observed flies and ants in the Alps. In Dumfriesshire, an Empid and a Muscid were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 68).

281. Sedum L.

Flowers protogynous, or homogamous to markedly protandrous; with half-concealed nectar, secreted basally between petals and stamens.

995. S. acre L. (Herm. Müller, 'Fertilisation,' pp. 251–3; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 289; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 74, 154, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234.)—The flowers of this species are bright yellow in colour, and the five outer stamens superposed to the sepals are the first to mature. They direct their filaments (about 5 mm. long) obliquely upwards. When they have shed their pollen they bend back towards the petals, while the five inner anthers dehisce, and assume the position of the first five. The small terminal stigmas of the five carpels do not mature till the inner anthers have shed all their pollen. I observed this marked protandry, which completely prevents self-pollination, in the island of Föhr.

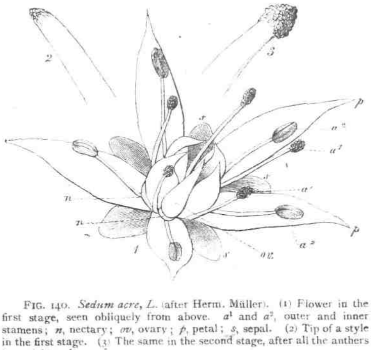


FIG. 140. *Sedum acre, L.* (after Herm. Müller). (1) Flower in the first stage, seen obliquely from above. a^1 and a^2, outer and inner stamens; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal. (2) Tip of a style in the first stage. (3) The same in the second stage, after all the anthers have dehisced.

Elsewhere the flowers are not so distinctly protandrous. Hermann Müller states that in Westphalia the stigmas mature before the five inner stamens have finished shedding their pollen, so that automatic self-pollination is possible if insect-visits fail.

VISITORS.—I observed the following in Schleswig-Holstein, all skg.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Calliphora erythrocephala *Mg.*; 3. Lucilia sp.; 4. Nemotelus uliginosus *L.* ♀; 5. Spilogaster carbonella *Zett.* (*b*) *Syrphidae*: 6. Eristalis tenax *L.*; 7. Melithreptus taeniatus *Mg.*; 8. Syritta pipiens

L.; 9. Syrphus balteatus *Deg.* ♂. **B. Hymenoptera.** 10. Andrena nigriceps *K.* ♀; 11. Bombus rajellus *K.* **C. Lepidoptera.** 12. Epinephele janira *L.* Also 2 Muscids (1. Lucilia caesar *L.*, and 2. Scatophaga stercoraria *L.*) and a Syrphid (Syrphus sp.), all skg., in Helgoland.

Herm. Müller noticed the following in Westphalia.—

A. Diptera. (*a*) *Muscidae*: 1. Pyrellia aenea *Zett.*, skg. (*b*) *Syrphidae*: 2. Eristalis tenax *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 3. Andrena cingulata *K.* ♀, skg.; 4. A. parvula *K.* ♀ and ♂, freq., skg.; 5. Bombus rajellus *K.* ☿, skg.; 6. Cilissa tricincta *K.* ♀, do.; 7. Megachile centuncularis *L.* ♀, po-cltg.; 8. M. circumcincta *K.* ♀, skg.; 9. Nomada ferruginata *K.* ♀, do.; 10. Prosopis armillata *Nyl.* ♂, do.; 11. P. brevicornis *Nyl.* ♂, do.; 12. P. variegata *F.* ♂, do.; 13. Sphecodes gibbus *L.* ♀, freq., skg.

The following were recorded by the authorities, and at the places stated.—

Alfken (Bremen), 3 bees (1. Andrena parvula *K.* ♀; 2. Halictus punctulatus *K.* ♀; 3. Prosopis hyalinata *Sm.* ♀), and a Syrphid (4. Melithreptus menthastri *L.*). Verhoeff (Norderney),—**A. Diptera.** (*a*) *Muscidae*: 1. Cynomyia mortuorum *L.* ♂, skg.; 2. Lucilia caesar *L.* ♂, do.; 3. Miltogramma sp., do.; 4. Sarcophaga striata *F.*, do. (*b*) *Syrphidae*: 5. Eristalis arbustorum *L.* ♀, skg.; 6. E. sepulcralis *L.* one ♀, do. **B. Hymenoptera.** *Sphegidae*: 7. Oxybelus uniglumis *L.* Schenck (Nassau) the bee Anthidium oblongatum *Ltr.* Rössler (Wiesbaden) the Tineid Glyphipteryx equitella *Scop.* Frey (Simplon) the butterfly Lycaena orion *Pall.* Herm. Müller (Alps) a humble-bee, 2 flies, and 3 Lepidoptera. MacLeod (Pyrenees) a Muscid. Scott-Elliot (Scotland) a humble-bee.

Schletterer saw the following **Hymenoptera** at Pola.—

(*a*) *Apidae*: 1. Andrena limbata *Ev.*; 2. Crocisa major *Mor.*; 3. Halictus variipes *Mor.*; 4. H. virescens *Lep.*; 5. Osmia fulviventris *Pz.*; 6. O. versicolor *Ltr.*; 7. Prosopis clypearis *Schenck.* (*b*) *Ichneumonidae*: 8. Anilasta rapax (Gr.) *Ths.* (*c*) *Sphegidae*: 9. Trypoxylon figulus *L.*

996. S. reflexum L. (= S. rupestre *L.*). (Herm. Müller, 'Fertilisation,' p. 253, 'Weit. Beob.,' p. 295.)—Hermann Müller states that the citron-yellow flowers of this species are imperfectly protandrous, like those of S. acre.

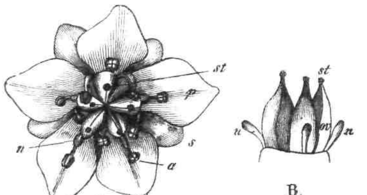


FIG. 141. *Sedum alpestre, Vill.* (after Herm. Müller). *A.* Flower in the first (female) stage (× 7). *B.* Three carpels of the same flower, with the attached nectaries; seen from without. *a*, anther; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., po-dvg. (Budd.). (*b*) *Syrphidae*: 2. Eristalis tenax *L.* (H.M.); 3. Syrphus arcuatus *Fall.*, skg. (Budd.). **B. Hymenoptera.** *Apidae*: 4. Anthidium oblongatum *Ltr.* ♂, skg. (Budd.); 5. A. punctatum *Ltr.* ♀ and ♂, in great numbers, skg. (Budd.); 6. Halictus morio *F.* ♀ skg. (Budd.); 7. H. sexnotatus *K.* ♀, do. (Budd.); 8. Megachile maritima *K.* ♂ (H. M.). **C. Lepidoptera.** *Rhopalocera*: 9. Epinephele janira *L.* ♂, skg. (Budd.); 10. Vanessa urticae *L.*, do. (Budd.).

Friese (Thuringia) noticed parasitic bees (1. Coelioxys elongata *Lep.*, and 2. Stelis signata *Ltr.*) and po-cltg. bees (3. Anthidium lituratum *Pz.*, and 4. A. punctatum *Ltr.*).

997. **S. boloniense** Loisel. (=S. sexangulare *L.*). (Schulz, 'Beiträge,' I. p. 39.)—Schulz states that in the yellow flowers of this species the stigmas are perfectly mature when the outer stamens are dehiscing. Automatic self-pollination is quite possible, for the stamens bend towards the stigmas; but would appear to be seldom resorted to, since numerous insects are attracted by the yellow colour of the blossoms, as well as by the abundant nectar, which is secreted as in S. acre.

998. **S. alpestre** Vill. (=S. repens *Schleich.*). (Herm. Müller, 'Alpenblumen,' pp. 82–3.)—This species is native to the high Alps. Its flowers are protogynous, but the stigmas continue functional till the anthers dehisce, so that automatic self-pollination is possible should insect-visits fail. (Cf. Fig. 141.)

VISITORS.—Herm. Müller observed 2 Hymenoptera, a Dipterid, and 2 Lepidoptera.

999. **S. albescens** Haw. (=S. rupestre *L.*)—

VISITORS.—MacLeod observed 2 bees (Bombus and Andrena) and a butterfly (Lycaena) in the Pyrenees.

1000. **S. annuum** L. (Schulz, 'Beiträge,' p. 77.)—The flowers of this species are mostly pale-yellow in colour. Schulz states that when they open the stigmas are

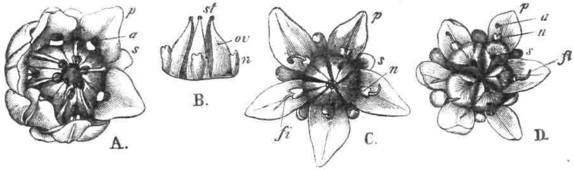


FIG. 142. *Sedum atratum*, *L.* (after Herm. Müller). *A.* Flower in the first (female) stage. *B.* Three carpels of the same, seen from without. *C.* Flower towards the end of the second (male) stage. *D.* Flower after fading. (× 7.) *a*, anther; *fi*, filament; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

receptive, remaining so throughout anthesis. The anthers of the outer stamens dehisce as soon as the flower opens, and then those of the inner ones. The stigmas and anthers being close together and at the same level, automatic self-pollination is at first possible, or even inevitable; but the inner stamens curve outwards towards the end of anthesis, thus favouring cross-pollination. Lindman too found the flowers to be protogynous at first, afterwards becoming homogamous and capable of automatic self-pollination. Kerner says that the outer stamens serve for self- and the inner ones for cross-pollination. He also states that this annual species hybernates by means of rosette-shaped offshoots, should winter set in early and prevent the ripening of fruits.

VISITORS.—Schulz observed occasional flies and Ichneumonids at Bozen.

1001. **S. atratum** L. (Ricca, Atti Soc. ital. sc. nat., Milano, xiii, 1870, p. 256; Herm. Müller, 'Alpenblumen,' pp. 79–80; Kerner, 'Nat. Hist. Pl.' Eng. Ed. 1, II.

pp. 175, 344.)—This species is native to the high Alps. Hermann Müller describes the flowers as protogynous, but with persistent stigmas, so that automatic self-pollination takes place normally and tolerably soon. Ricca says the flowers are protogynous with short-lived stigmas. Kerner adds that anthesis lasts four days, that the outer stamens serve for cross- and the inner ones for self-pollination, and that the scale-like nectaries are cleft at the tip. (Cf. Fig. 142.)

VISITORS.—Herm. Müller only observed a Chrysidid and a Pyralid.

1002. S. Telephium L. (Herm. Müller, 'Fertilisation,' pp. 253–4.)—The two species (S. maximum *Suter* and S. purpureum *Link*) into which S. Telephium is now divided possess the same flower mechanism, except that the inner stamens of S. purpureum are inserted into the petals one-sixth of the way up. Hermann Müller states that the anthers of the five outer stamens dehisce first, and then those of the five inner ones; and it is only when the latter have withered that the stigmatic papillae develop. The stamens lie close to the widely radiating petals, so that self-pollination is excluded even if some pollen remains clinging to the anthers until the stigmas are mature.

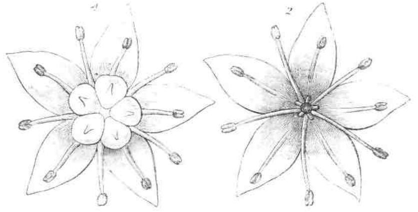


FIG. 143. *Sedum Telephium, L.* (after Herm. Müller). (1) Flower seen from above. (2) The same after removal of the carpels, to show the five nectaries.

The nectaries are situated as in S. acre, but their form is somewhat different: in S. Telephium, they are on the tips of longish scales at the bases of the petals and below the ovaries. Nectar-sucking or pollen-collecting insects that creep about on the crowded inflorescences touch the anthers and stigmas of numerous flowers in succession, and since these are protandrous effect crossing: they may also, however, occasionally effect self-pollination in old flowers with mature stigmas, should some pollen still cling to the anthers.

VISITORS.—Herm. Müller observed the following.—

A. Diptera. *Muscidae*: 1. Echinomyia magnicornis *Zett.*, skg. **B. Hymenoptera.** (*a*) *Apidae*: 2. Bombus agrorum *F.* ♂, skg.; 3. B. lapidarius *L.* ☿, po-cltg.; 4. B. sylvarum *L.* ♀ and ☿, in great numbers, skg.; 5. Halictus zonulus *Sm.* ♀, skg.; 6. Psithyrus campestris *Pz.* ♂, do. (*b*) *Tenthredinidae*: 7. Allantus arcuatus *Forst.* (Borgstette).

MacLeod saw Bombus terrester *L.* ☿, po-cltg. and skg., in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 419).

Alfken noticed Bombus agrorum *F.* ♂ at Bremen.

Loew observed the following visitors in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg.; 3. Bombus sylvarum *L.* ♀, do.; 4. B. terrester *L.* ♂, do.

1003. S. dasyphyllum L. (Schulz, 'Beiträge,' II, pp. 77–8.)—The flowers of this species are white with a reddish tinge. Schulz describes them as protandrous, to a degree inversely proportional to the height of the habitat above sea-level: the plants of low-lying districts are most markedly so. In such places (e. g. in the Etschthal) the styles with their immature stigmas lie close together at the time when the flower opens: the stigmas only become receptive when the anthers have shed all their pollen, often indeed, only when they have dropped off: it follows that self-pollination is almost entirely excluded. In higher regions (e. g. the Ortler district), the stigmas ripen somewhat sooner, so that automatic self-pollination is usually tolerably easy when they spread out.

Kerner states that the stigmas are receptive when the flower opens; and that the outer stamens serve for cross-, the inner ones for self-pollination. It appears, therefore, that homogamy also obtains.

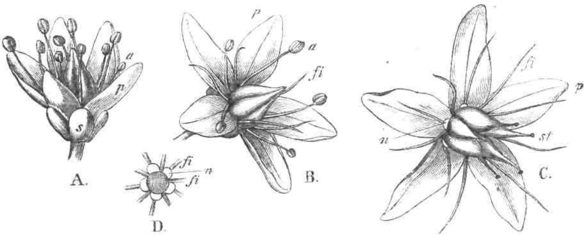


FIG. 144. *Sedum album*, *L.* (after Herm. Müller). *A.* Just opened flower. *B.* Flower in the second half of the first (male) stage. *C.* Flower in the second (female) stage. *D.* Centre of the flower, after removal of the carpels. (× 7.) *a*, anther; *fi*, filament; *n*, nectary; *p*, petal; *s*, sepal; *st*, stigma.

The nectaries are small, heart-shaped, stalked scales, yellow or orange-red in colour, and placed opposite the ovaries.

Visitors.—Schulz observed numerous short-tongued insects (flies and the smaller Hymenoptera), but does not record their species. MacLeod saw a bee in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 418).

1004. S. altissimum Poir. (= S. nicaeënse *All.*)—The flowers of this species are yellow.

Visitors.—MacLeod saw a bee (Halictus morio) in the Pyrenees.

1005. S. album L. (Herm. Müller, 'Weit. Beob.,' I, p. 296, 'Alpenblumen,' pp. 80–1; Schulz, 'Beiträge,' I, p. 77; Loew, 'Blütenbiol. Floristik,' p. 397.)—The flowers of this species are distinctly protandrous, and Hermann Müller says that self-pollination is scarcely possible. Schulz confirms this statement for the Tyrol. (Cf. Fig. 144.)

Visitors.—Herm. Müller (Alps) saw 3 beetles, 7 flies, 2 bees, and 3 Lepidoptera.

Herm. Müller (H. M.) in the Fichtelgebirge and Buddeberg (Budd.) in Nassau also observed the following.—

A. Coleoptera. (*a*) *Byrrhidae*: 1. Byrrhus pilula *L.*, skg. (H. M.). (*b*) *Cerambycidae*: 2. Leptura maculicornis *Deg.*, freq., skg. (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 3. Bombylius canescens *Mikan*, skg. (Budd.). (*b*) *Muscidae*: 4. Echinomyia fera *L.*, skg. (H. M.); 5. E. grossa *L.*, do. (H. M.). **C. Hymenoptera.** *Apidae*: 6. Chelostoma campanularum *K.* ♀, skg. (Budd.); 7. Halictus albipes *F.* ♂, do. (H. M.); 8. H. flavipes *F.* ♀, do. (H. M.); 9. H. interruptus *Pz.* ♀, do. (Budd.); 10. Prosopis armillata *Nyl.* ♀, do. (Budd.); 11. P. signata *Pz.* ♂, do. (H. M.); 12. Psithyrus quadricolor *Lep.* ♂, do. (H. M.).

Schenck saw the bee Anthidium lituratum *Pz.*, and quotes Friese as recording the parasitic bee Stelis signata *Ltr.* for Nassau.

Loew observed the following in Switzerland.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Stenopterus rufus *L.*; 2. Strangalia armata *Hbst.*; 3. S. melanura *L.* (*b*) *Cleridae*: 4. Trichodes apiarius *L.* (*c*) *Oedemeridae*: 5. Oedemera coerulea *L.*; 6. O. flavescens *L.*; 7. O. flavipes *F.* **B. Hymenoptera.** *Apidae*: 8. Prosopis alpina *Mor.* **C. Lepidoptera.** (*a*) *Sesiidae*: 9. Sesia formicaeformis *Esp.* (*b*) *Zygaenidae*: 10. Syntomis phegea *L.*; 11. Zygaena filipendulae *L.*

F. F. Kohl noticed 3 wasps (1. Vespa crabro *L.*, 2. Eumenes pomaformis *F.*, and 3. Odynerus bidentatus *Lep.*) in the Tyrol.

MacLeod saw 2 Lepidoptera, 7 beetles, and 13 flies in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 419).

1006. S. Aizoon L.—

VISITORS.—Loew noticed the humble-bee Bombus lapidarius *L.* ☿., skg., in the Berlin Botanic Garden.

1007. S. spectabile Ber.—

VISITORS.—Loew observed a Syrphid (Eristalis tenax *L.*) and a bee (Halictus minutissimus *K.* ♀) in the Berlin Botanic Garden.

1008. S. anglicum Huds.—The flowers of this species are of a whitish-rose colour.

VISITORS.—MacLeod saw a bee, a beetle, a Syrphid, and a Muscid in the Pyrenees.

In Dumfriesshire 2 Stratiomyids and a Muscid were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 69).

282. Sempervivum Rupp.

Flowers protandrous, red or yellowish-white; with concealed nectar secreted at the bases of the carpels.

1009. S. Wulfeni Hoppe. (Herm. Müller, 'Alpenblumen,' pp. 83–4; Schulz, 'Beiträge,' II, pp. 79–80.)—Hermann Müller describes the flowers of this species as being so markedly protandrous that automatic self-pollination appears to be excluded. According to A. Schulz, who also studied the plants in the Ortler district, the protandry is not so marked, autogamy sometimes taking place, though perhaps not often.

The abundant nectar is secreted by a disk beneath the pistil, and is protected from rain by hairs.

VISITORS.—Herm. Müller states that the nectar is specially sought out by bees (8 species), more rarely by Ichneumonids (1), beetles (1), and hover-flies (2). Schulz mentions flies, bees, and Lepidoptera as frequent; beetles as less so.

1010. **S. Funckii** F. Braun. (Herm. Müller, 'Alpenblumen,' pp. 84–6.)—The flowers of this species are also protandrous, but individual stigmas often become receptive when only the first stamens have withered, so that self-pollination is commoner than in S. Wulfeni. (Cf. Fig. 145.)

VISITORS.—Herm. Müller observed 2 beetles, 6 bees, 9 Lepidoptera, and 3 flies.

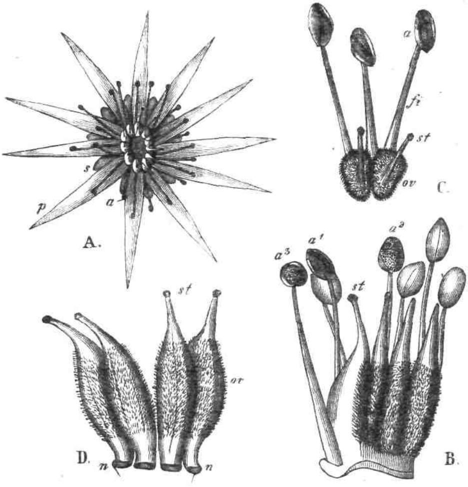


FIG. 145. *Sempervivum Funckii, Braun* (after Herm. Müller). *A*. Flower in the second (female) stage (× 2½). *B*. Part of the reproductive organs in the first (predominatingly male) stage (× 7). *C*. Part of the same in the second (purely female) stage. *D*. A few carpels with mature stigmas. *a–a³*, anthers; *fi*, filament; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

1011. **S. montanum** L. (Herm. Müller, 'Alpenblumen,' p. 86; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 344–5.)—The flower mechanism of this species agrees with that of S. Funckii. Kerner states that the inner anthers do not dehisce till the stigmas have withered, so that they serve for cross-pollination, while the outer ones are concerned with autogamy.

Visitors.—Herm. Müller saw a bee and 4 Lepidoptera in the Heuthal. Loew noticed a Noctuid (Agrotis ocellina *S. V.*) in the same locality. Alfken observed the bee Anthidium manicatum *L.* ♀ and ♂, very freq., skg., at Bremen.

1012. **S. tectorum** L. (Herm. Müller, 'Alpenblumen,' pp. 86–7; Schulz, 'Beiträge,' II, p. 79.)—Hermann Müller says that the flower mechanism of this species agrees with that of S. Funckii. According to Schulz, the stigmas do not usually become receptive till the anthers have shed all their pollen, so that self-pollination is excluded.

Visitors.—Herm. Müller saw 3 beetles, 6 bees, and 7 Lepidoptera. Schulz observed humble-bees and other Hymenoptera, more rarely Lepidoptera and flies.

1013. **S. arachnoideum** L. (Herm. Müller, 'Alpenblumen,' p. 87.)—In the flowers of this species, according to the observations of Hermann Müller (made in the canton of Graubünden), the styles are often apposed till the anthers have all discharged their pollen. Schulz ('Beiträge') states that the styles (in the Tyrol) are often inclined towards one another when the flower opens, but subsequently spread out gradually till they occupy an almost horizontal position. The stigmas are usually receptive at the time when the last of the inner stamens shed their pollen, so that automatic self-pollination may be effected.

Visitors.—Herm. Müller observed 8 flies, 7 bees, and 11 Lepidoptera. Schulz also observed Lepidoptera (3), bees, and flies.

1014. **S. ruthenicum** Koch.—Kerner states that in this species the inner stamens serve for cross-pollination, while the outer ones bend towards the stigmas and bring about autogamy.

283. **Bryophyllum** Salisb.

1015. **B. calycinum** Salisb. (Delpino, 'Altri appar. dicog. recent. oss.,' p. 56.)—Delpino states that the elongated tubular and pendulous flowers of this species secrete abundant nectar from four glands. They are protandrous.

Visitors.—Delpino supposes these to be humming-birds, despite the inconspicuous greenish or brownish colour of the flowers.

284. **Cotyledon** Tourn.

1016. **C. umbilicus** L. (Willis, 'Contributions to the Nat. Hist. of the Flower,' (2).)—The corolla-tube of this species is about 10 mm. deep and 3 mm. wide, and the nectar is secreted in its base by the five carpels. The ten anthers dehisce when the flower opens. They are at the same level as the stigmas, though these are at first not fully mature. It follows that insects probing for nectar in the first stage of anthesis cover themselves with pollen, which they transfer to the stigmas of flowers in the second stage. Towards the end of anthesis automatic self-pollination is inevitable, owing to the proximity of stigmas and anthers.

Visitors.—Willis only observed Thrips.

XXXVII. ORDER *DROSERACEAE* DC.

285. Drosera L.

Most of the flowers, according to my observations in Schleswig-Holstein, are cleistogamous (cf. Vol. I, p. 54). It is only in very favourable continuously sunny weather that the small white blossoms open, and anthesis is confined to a single morning. Hansgirg describes the species of this genus as pseudo-cleistogamous.

Kerner states that nectar is secreted by the yellow claws of the petals in the chasmogamous flowers. After the brief anthesis the flowers close again, and the six stigmatic lobes of the style curve in such a way that their receptive papillae touch the pollen-covered anthers. This self-pollination is effective.

1017. D. rotundifolia L. (Kirchner, 'Flora v. Stuttgart,' p. 322; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 34.)—The white flowers of this species open but rarely, and are only 3 mm. in diameter, so that there can scarcely be any question of insect-visits. The five anthers dehisce when the flower opens, and are at the same level as the simultaneously matured stigmas, from which they are only ½ mm. distant, so that automatic self-pollination can easily take place, especially when the flower closes towards the end of anthesis. Either cross- or self-pollination may be effected by insect-visits to the open flowers. In those which remain closed the stamens and carpels touch one another when mature. Such cleistogamous flowers produce abundant seed.

Visitors.—In Dumfriesshire, several Muscids were observed (Scott-Elliot, 'Flora of Dumfriesshire,' p. 73).

1018. D. intermedia Hayne. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 34.)—The flower mechanism of this species agrees with that of D. rotundifolia. Cleistogamous flowers are even more frequent.

1019. D. anglica Huds. (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The flowers of this species are mostly pseudo-cleistogamous, many of them opening about mid-day, but soon closing again. The stigmatic branches and the anthers mature simultaneously before anthesis; the latter are very small, and borne upon thick filaments. The pollen-grains are golden-yellow in colour, densely covered with spinous tubercles, and aggregated into 3–4 celled pollinia.

286. Aldrovanda Mont.

The flowers are mostly cleistogamous, according to Bentham and Hooker.

1020. A. vesiculosa L. (Korzchinsky, 'Zur Kenntnis der Aldrovanda vesiculosa.')—Korzchinsky states that in the flowers of this species each anther contains at most thirty-five pollen-grains. The anthers get bound to the stigma by pollen-tubes, but most of the ovules remain unfertilized, even though they swell up with the ovary.

XXXVIII. ORDER *BRUNIACEAE* R. Br.

The flowers are aggregated into small capitula, and their mechanism resembles that of the Compositae. According to Delpino ('Ult. oss.,' p. 98) and Hildebrand (Bot. Ztg., Leipzig, xxviii, 1870, p. 636), the end of the style bears a glabrous bilobed collecting-cup, which grows through the anther-tube and thus takes up the pollen. The stigmatic surface appears upon it later.

XXXIX. ORDER *HALORAGEAE* R. Br.

(including HIPPURIDACEAE Link, GUNNERACEAE Endl., and CALLITRICHACEAE Link.)

287. Myriophyllum L.

Monoecious wind-pollinated water-plants. The anthers are versatile, and contain abundant easily dispersed pollen. The stigmas are large, and very rough. Some of the species are possibly water-pollinated.

1021. M. verticillatum L. (Ludwig, Kosmos, Stuttgart, x, 1881–2, pp. 7–12.)—The small, greenish-yellow flowers of this species are arranged in spiked whorls in the leaf-axils. They project above water, and are wind-pollinated. Ludwig states that there are also submerged water-pollinated flowers. These, however, do not appear to be universally distributed: at any rate I did not observe them in the island of Föhr.

1022. M. spicatum L. (Ludwig, op. cit.)—Ludwig says that the reddish flowers of this species possess the same mechanism as those of M. verticillatum, but submerged flowers have not been observed. According to Kerner, the female flowers develop before the male ones.

Only sterile plants of the species had been observed in Greenland, until Vanhöffen discovered richly flowering specimens in a pond at Ikerusak (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 11–12). As in Europe, the stigmas of the female flowers were mature before the opening of the male ones.

1023. M. alterniflorum DC.—Here again only wind-pollinated flowers projecting above the water-level have so far been observed.

288. Hippuris L.

Water-plants with inconspicuous protogynous wind-pollinated flowers in the leaf-axils.

1024. H. vulgaris L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 171–2.)—In this species the part of the stem projecting from the water bears on each of its nodes (fifty to sixty, or even more in number) a whorl of ten leaves. There is a small flower in the axil of each of these. At first the white, very papillose stigma projects 3 mm. beyond the ovary, while the sessile anther is still closed. When the stigma has withered a thin filament ($1\frac{1}{2}$ mm. long) develops, and at its tip the dehisced anther exposes its pollen to the wind. I am unable to confirm Vaucher's assertion ('Hist. physiolog. des pl. d'Europe,' II, p. 362), that the oily yellow pollen is directly applied to the stigma.

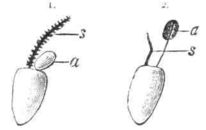


FIG. 146. *Hippuris vulgaris*, *L.* (from nature, several times enlarged). (1) Flower in the first (female) stage: *a*, sessile, immature anther; *s*, papillose stigma. (2) Flower in the second (male) stage: *a*, stalked dehisced anther; *s*, withered stigma.

In Föhr, besides hermaphrodite stocks, I observed others that were purely female, or on which only some flowers possessed stamens. Kirchner also observed gynodioecism at Stuttgart ('Flora v. Stuttgart,' p. 419), as did Willis in England (Proc. Phil. Soc., Cambridge, 1893).

Vanhöffen states that the species flowers and fruits normally in Greenland between 60° and 70° N. lat. (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 12).

289. Gunnera L.

1025. G. manicata Linden. (Jonas, 'Über d. Inflores. u. Bl. v. Gunnera manicata,' Inaug.-Dissert., Breslau, 1892.)—Jonas describes this species as gynomonoecious. Nectaries are absent. The hermaphrodite flowers are anemophilous, and they alone set ripe fruits.

290. Callitriche L.

This genus includes inconspicuous monoecious species; anemophilous and protogynous so far as my own observations go, but generally described as entomophilous or hydrophilous in some instances.

1026. C. vernalis Kuetz. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 72.)—This species is anemophilous and obviously protogynous in the North Frisian Islands, for pollen remains clinging to the anthers of the male flowers when the female ones in the same plant have already set fruits. I have not observed the early stages of anthesis.

1027. C. stagnalis Scop. (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 36; Knuth, op. cit., p. 72; Hegelmaier, 'Monographie d. Gatt. Callitriche,' Stuttgart, 1864; Ludwig, Kosmos, Stuttgart, x. 1881–2, p. 32; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In the North Frisian Islands this species also is anemophilous and protogynous. Hegelmaier describes the flowers as anemophilous, but also says they are protandrous, the male flowers maturing before the female ones of the same inflorescence. The former are mostly situated in the axils of the upper leaves, and the latter in those of the lower ones. The pollen-grains are covered with a thick, somewhat tuberculated membrane.

Ludwig says that in this species and the other Eucallitricheae (C. vernalis and C. hamulata) the fibrous anther-layer characteristic of aerial flowers is present, a layer which plays an important part in dehiscence. He describes the stamens as 1 mm. long, with stiff filaments, and producing pollen-grains about 25 μ long and 21 μ broad. The two styles are almost entirely covered with papillae.

Besides aerial flowers Ludwig also observed submerged ones, fertilized under the surface of the water. Hegelmaier found such flowers to be infertile, and Kerner says that their anthers do not usually dehisce, but decay with the pollen they contain. The flowers of terrestrial stocks growing in mud or damp woods behave like those of aquatic ones.

Warnstorf describes the flower mechanism of the variety (a) *vera* Aschs. somewhat as follows.—Owing to the extreme shortening of the terminal nodes of the shoots, the opposite leaves are crowded into a floating rosette. The diclinous (monoecious) flowers are situated in their axils. As a rule the female flowers first make their appearance. The two long styles are beset with stigmatic papillae for two-thirds of their length, and project for about 3 mm. beyond the leaves of the rosette. After pollination and elongation of the nodes the flowers become submerged and ripen their fruits. At a later stage the male flowers appear in their

axils, each with a single stamen 4–5 mm. long, the yellow anther of which is borne upon a stiff filament and projects from the rosette to this distance, afterwards dehiscing. The pale-yellow tuberculated pollen-grains are very irregular in shape (prismatic, tetrahedral, or bluntly pyramidal), very easily scattered, and transferred by the wind to adjoining younger leaf-rosettes bearing female flowers. In rarer cases I noticed a male flower in one leaf-axil and a female flower in that immediately opposite. Self-pollination was then easily possible, for pollen could fall directly on the two branches of the style. Besides the anemophilous flowers now described I also found, on lateral shoots of varying length, female flowers devoid of perianth leaves, relatively small ovaries and very long styles. These were apparently pollinated under water, though I did not observe submerged male flowers. The species may therefore be described as anemo-hydrophilous, and autogamous under certain conditions.

1028. **C. hamulata** Kuetz. (Ludwig, op. cit.; Hegelmaier, op. cit.)—This species also bears submerged flowers, which are sterile according to Hegelmaier.

1029. **C. autumnalis** L. (Ludwig, op. cit; Hegelmaier, op. cit., p. 61; Jönsson, Univ. Årsskr., Lund, xx, 1883–4.)—This species belongs to the sub-genus *Pseudocallitriche*, in which the pollen-grains possess no external coat (extine), an indication of hydrophily. Jönsson describes them as oil-containing and lighter than water, so that they can drift to the stigmas of the female flowers and effect pollination.

XL. ORDER *MELASTOMACEAE* R. Br.

291. Heeria Schlecht.

Hermann Müller states (Nature, London, xxiv, 1881, pp. 307–8) that in the species of this genus there are two kinds of stamen differing in function: the one kind serving to attract insects, while the other produces pollen. (*Cf.* Vol. I, p. 108.)

292. Centradenia G. Don (1030. C. floribunda Planch.), 293. Rhexia L. (1031. R. glandulosa Bertol.), and 294. Monochaetum Naud. (1032. M. ensiferum Naud.)—

Darwin describes the above three species as self-sterile.

295. Pleroma D. Don (=Tibouchina *Aubl.*).

1033. **P. Sellowiana** Cogn. (Ludwig, Biol. Centralbl., Erlangen, vi, 1886–7.)—Ludwig says that the flowers of this species are at first pure white, afterwards assuming a purple-red colour. (*Cf.* Vol. I, p. 86.)

Darwin describes species of Pleroma as self-sterile.

XLI. ORDER *LYTHRARIEAE* JUSS.

(including Granateae Don.)

This order includes a large number of trimorphous and dimorphous species. Among the former are Lythrum Salicaria *L.*, L. Graefferi *Tenore*, and species of the genera Nesaea and Lagerstroemia. Among dimorphous forms are Lythrum

Thymifolia *L.* (homomorphous according to Koehne), and twenty other species of the same genus, as well as some belonging to the genera Pemphis, Rotala, and Nesaea. (*Cf.* Vol. I, p. 491.) Numerous species are homomorphous, among which Koehne enumerates no fewer than 340 belonging to Lythrum, including our native species L. Hyssopifolia *L.*

Koehne gives the following particulars in his newest monograph of the order ('Lythraceae,' in Engler u. Prantl, d. nat. Pflanzenfam., III, 7, pp. 4–5).—Eight species exhibit trimorphous heterostyly (Lythrum maculatum *Kjærsk.*, L. flexuosum *Lag.*, L. virgatum *L.*, L. Salicaria *L.*, Nesaea Kilimandscharica *Koehne* (?), N. Schinzii *Koehne*, N. sagittifolia (Sond.) *Koehne*, Decodon verticillatum (L.) Ell.) and possess two whorls of stamens. Dimorphous heterostyly obtains in five species possessing two staminal whorls (Lythrum rotundifolium *Hochst.*, Pemphis acidula *Forst.*, Nesaea rigidula (Sond.) *Koehne*, N. mucronata *Koehne*, N. Volkensii *Koehne*).

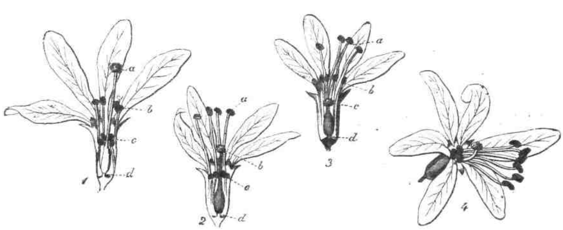


FIG. 147. *Lythrum Salicaria, L.* (after Herm. Müller). (1) Long-styled flower, after removal of one-third of the calyx, corolla, and stamens; seen from above. (Pollen green.) (2) Medium-styled flower, ditto. (Pollen yellow.) (3) Short-styled flower, ditto. (Pollen yellow.) (4) Medium-styled flower, seen obliquely from the right front. *a*, long style or stamens; *b*, medium style or stamens; *c*, short style or stamens; *d*, nectar.

The following fourteen species possessing but one whorl of stamens are dimorphously heterostylous (Rotala myriophylloides *Welw.*, R. floribunda (night) *Koehne*, R. nummularia *Welw.*, Lythrum lineare *L.*, L. album *H. B. and K.*, L. ovalifolium (Engelm.) *Koehne*, L. acinifolium (DC.) *Koehne*, L. gracile *Benth.*, L. lanceolatum *L.*, L. californicum *S. Wats.*, L. alatum *Pursh*, L. Vulneraria *Ait.*, Nesaea lythroides *Welw.*, N. Woodii *Koehne*). About 6% of the 450 species included in the order are heterostylous. The most specialized forms as regards pollination are the strongly zygomorphous flowers of species of Cuphea and Pleurophora.

Some species bear cleistogamous or pseudo-cleistogamous flowers. Ammannia latifolia *L.*, for instance, is often cleistogamous, according to Koehne. Treviranus states that the following are self-pollinated before their flowers open:—Cuphea silenoides *Nees*, C. floribunda *Lelm.*, and C. Melvilla *Lindl.* (Bot. Ztg., Leipzig, xxi, 1863).

296. Lythrum L.

Flowers red, trimorphous, dimorphous, or homomorphous; with concealed nectar, secreted at the bottom of the tubular receptacle.

1034. L. Salicaria L. (Charles Darwin, 'On the Sexual Relations of the three Forms of Lythrum Salicaria,' J. Linn. Soc. Bot., London, viii, 1865, pp. 169–96, 'Different Forms of Flowers'; Herm. Müller, 'Fertilisation,' pp. 255–60.)—Charles Darwin investigated the flower mechanism of this species in an extremely thorough manner, and proved by numerous experiments that the 'reproductive organs, when of different length, behave to one another like different species of the same genus in regard both to direct productiveness and the character of the offspring; and that consequently mutual barrenness, which was once thought conclusive proof of difference of species is worthless as such, and the last barrier that was raised between species and varieties is broken down' (Herm. Müller, op. cit., p. 258).

Before considering Darwin's experiments in detail, a description of the flower mechanism will be given.

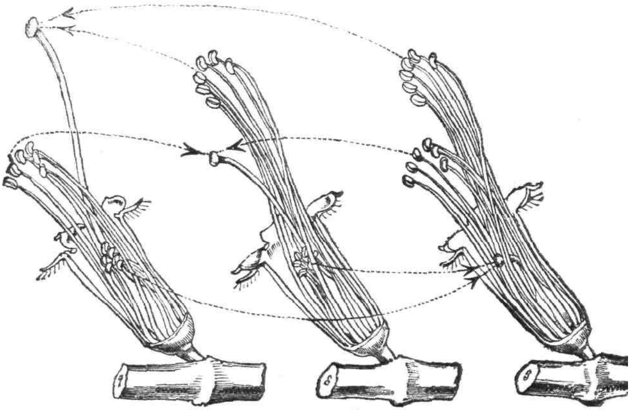


FIG. 148. Scheme of the legitimate unions possible in *Lythrum* (after Charles Darwin). *A.* Long-styled form. *B.* Medium-styled form. *C.* Short-styled form. The dotted lines indicate the anthers from which pollen must pass to the stigma of each of the three forms, so as to give a legitimate union with complete fertility.

Hermann Müller says that the nectar is secreted by the fleshy base of the receptacle, surrounding the short stalk of the ovary, and filling the space between this and the receptacular wall. The red inner surface of the calyx, and the dark veins of the petals (which converge to the middle of the flower), serve as nectar-guides. The flowers are horizontal, usually hexamerous (more rarely pentamerous), and not strictly actinomorphous. The petals are inserted into the edge of the cylindrical receptacle (5–7 mm. long), and the three lower petals are usually somewhat longer than the upper ones, which are 6–10 mm. in length. When the flower

has completely opened, the lower petals are directed somewhat obliquely forward, while the upper petals spread out vertically. The stamens and style are on the lower side of the flower, so that a nectar-seeking insect cannot penetrate between them, but has to insert its proboscis above them into the base of the receptacle. The ends of these organs bend upwards in such a way that the insect is obliged to touch the stigma and anthers.

Owing to the varying relative lengths of the stamens and style, nectar-seeking insects normally effect the crossing of different stocks. In each flower the two whorls of stamens and the style are at three different levels: the shortest of these are concealed in the receptacle, those of medium length project 3–4 mm., and the longest 7–8 mm. There are therefore the three following forms of flower.—

1. *Long-styled flowers*: the style is longer than the stamens; half of the latter are of medium length, the others short.
2. *Medium-styled flowers*: the style is of medium length; half of the stamens are longer than the style, the others shorter.
3. *Short-styled flowers*: the style is short; half of the stamens are long, the others of medium length.

The anthers of the long stamens are green in colour, possibly as a protection against pollen-devouring insects; those of the medium and short stamens are yellow. The long stamens produce the largest pollen-grains, the medium stamens grains of medium size, and the short stamens the smallest grains. In correspondence with this the stigmatic papillae of the long styles are distinctly longer than those of the medium and short styles.

The experiments of Darwin, to which reference has been made, show that of the eighteen possible modes of fertilization (*cf.* Vol. I, p. 47) only those six lead to complete fertility in which each kind of stigma receives pollen from anthers situated at a corresponding level ('legitimate union,' *cf.* Fig. 148).

Insects of a size adapted to the flower mechanism (medium-sized bees, and certain hover-flies) regularly bring about legitimate fertilization when they probe for the nectar secreted in the fleshy base of the receptacle. Holding firmly to the long and medium organs, they thrust their proboscis into the receptacle, so that after visiting the various kinds of flower, three different parts of their proboscis and body are dusted with pollen, which is rubbed off on stigmas occupying the three corresponding levels.

VISITORS.—The most noteworthy is a bee, Melitta (Cilissa) melanura *Nyl.* ♀ and ♂, which Herm. Müller (op. cit., p. 259) observed 'wherever *Lythrum Salicaria* grows, both sucking honey and gathering pollen, and almost confining itself to this one plant.' Curiously enough, however, I myself have never succeeded in seeing this bee on the flowers, though I have often watched them in Schleswig-Holstein, Mecklenburg, and the island of Rügen, under very favourable conditions (in calm weather, and during sunshine). Herm. Müller (loc. cit.) adds, 'Since its proboscis is only 3–4 mm. long, it must thrust a great part of its head, which is 2–3 mm. broad, into the tube: it then touches the shortest reproductive organs with the under-surface of its head, the next with the ventral surface of its thorax, and the longest with the ventral surface of its abdomen; so that its dimensions suit the flower,

just as well as the flower must suit it, for the insect to confine its visits so exclusively to it. I have only found one exception to this exclusiveness, for I once found a male of Melitta (Cilissa) melanura sucking honey on *Thrincia hirta* DC.'

Friese saw the rare bee Melitta (Cilissa) haemorrhoidalis *F.*, var. nigra *Friese*, in Switzerland (canton Valais).

Herm. Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) have observed, in addition, the following.—

(Insects regularly effecting all three kinds of legitimate union are indicated by an asterisk (*); those which regularly effect only one or two kinds of legitimate union are not specially designated; the names of those which only effect pollination accidentally, bringing about either legitimate or illegitimate union, are enclosed in brackets [ ].)—

A. Coleoptera. (*a*) *Curculionidae*: 1. [Nanophyes lythri *F.* (H. M.)]. (*b*) *Nitidulidae*: 2. [Meligethes (H. M., Kn.)]. **B. Diptera.** *Syrphidae*: 3. Eristalis intricarius *L.*, po-dvg. (H. M.); 4. E. sp. (Kn.); 5. *Helophilus pendulus *L.*, skg. (H. M., Kn.); 6. *H. trivittatus *F.*, do. (H. M.); 7. [Melithreptus taeniatus *Mg.*, po-dvg. (H. M.)]; 8. Rhingia rostrata *L.*, skg. and po-dvg. (H. M., Kn.); 9. Syritta pipiens *L.*, do. (H. M., Kn.); 10. Syrphus balteatus *Deg.*, do. (H. M., Budd., Kn.); 11. S. ribesii *L.* (Kn.); 12. Volucella bombylans *L.*, skg. and po-dvg. (Kn.); 13. *V. bombylans *L.*, var. plumata *Mg.*, skg. (H. M.). **C. Hemiptera.** 14. [Capsus (H. M.)]. **D. Hymenoptera.** *Apidae*: 15. *Apis mellifica *L.* ☿, skg. (H. M., Kn.); 16. *Bombus agrorum *F.* ☿ and ♀, not infrequent, skg. (H. M., Kn.); 17. *B. derhamellus *K.* ☿ (Föhr, Kn.); 18. *B. lapidarius *L.* ♀, ☿ and ♂, skg. (H. M., Kn.); 19. *B. sylvarum *L.* ☿, do. (H. M.); 20. *B. terrester *L.* ♀ and ☿, do. (H. M., Kn.); 21. Chelostoma nigricorne *Nyl.* ♀, do. (Budd.); 22. *Cilissa melanura *Nyl.* ♀ and ♂, skg. and po-cltg. (H. M., Budd.); 23. [Halictus cylindricus *F.* ♀, po-cltg. (H. M.)]; 24. [H. leucopus *K.* ♀, skg. (Budd.)]; 25. [H. leucozonius *Schr.* ♀ and ♂, do. (Budd.)]; 26. [H. minutissimus *K.* ♀, do. (H. M.)]; 27. [H. morio *F.* ♀, do. (Budd.)]; 28. Megachile centuncularis *L.* ♂, do. (H. M.); 29. *M. fasciata *Sm.* ♂, do. (H. M.); 30. *Osmia adunca *Panz.* ♂, do. (Budd.); 31. *Saropoda rotundata *Pz.* ♂ and ♀, not infrequent, skg. (H. M.). **E. Lepidoptera.** (*a*) *Geometridae*: 32. Timandra amata *L.*, skg. (Budd.). (*b*) *Rhopalocera*: 33. Pieris rapae *L.*, freq., skg. (H. M., Kn.); 34. Rhodocera rhamni *L.*, do. (H. M.). **F. Thysanoptera.** 35. [Thrips (H. M.)].

The following were observed by the authorities, and for the localities named.—

Loew (Silesia) a bee (Bombus agrorum *F.* ♀, skg.), a Microlepidopterid (undetermined sp., skg.), and a butterfly (Pieris brassicae *L.*, skg.) ('Beiträge,' p. 32). Alfken (Bremen) a Curculionid (Nanophyes lythri *F.*, in vast numbers), and 3 bees (Bombus derhamellus *K.* ☿; B. distinguendus *Mor.* ♀, skg.; and Halictus calceatus *Scop.* ♂). Wüstnei (Schleswig) the bee Macropis labiata *Pz.* Friese (Baden (B.), Alsace (A.), Fiume (F.), Mecklenburg (M.), Switzerland (S.), and Hungary (H.)) the bees—1. Epeoloides caecutiens *F.* (F. and M., very rare S.); 2. Eucera basalis *Mor.* (F., according to Korlevič); 3. E. salicariae *Lep.*, not uncommon (A., S., H., Tyrol); 4. Melitta (Cilissa) melanura *Nyl.* (B., F., M., and H., occasional, A. rare). Rössler (Wiesbaden) the Lepidoptera Earias chlorana *L.*, and Orthosia lota *Cl.* Von Fricken (Westphalia and E. Prussia) the Curculionid Nanophyes lythri *F.* Schletterer (Tyrol) the bees—1. Bombus variabilis *Schmiedekn.*; 2. Halictus maculatus *Sm.*; Melitta (Cilissa) melanura *Nyl.* (also seen there by von Dalla Torre). Redtenbacher (Vienna) the Curculionid Nanophyes lythri *F.* Ducke (Aquileja (A.) and Austrian Silesia (S.)) the bees—1. Eucera (Macrocera) dentata *Klug.* ♂ (A.); 2. E. (M.) salicariae *Lep.* ♀ and ♂ (A.); Melitta (Cilissa) melanura *Nyl.* (S.). H. de Vries (Netherlands) a humble-bee, Bombus terrester *L.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). MacLeod (Flanders)

6 humble-bees, 5 hover-flies, and 5 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 393). Thomson (Sweden) the rare bee Melitta (Cilissa) melanura *Nyl.* Scott-Elliot (Dumfriesshire) Apis, 2 humble-bees, a hover-fly, and a Lepidopterid ('Flora of Dumfriesshire,' p. 68). Loew (Berlin Botanic Garden) 2 hover-flies, skg. (Melanostoma mellina *L.*, and Syrphus pyrastri *L.*), and a bee (Apis mellifica *L.* ☿, skg.); and, on the var. angustifolia, 2 bees, skg. (Apis, and Bombus agrorum *F.* ♂).

Heinsius noticed the following, all skg., in Holland.—

A. Hymenoptera. (*a*) *Apidae*: 1. *Apis mellifica *L.* ☿; 2. *Bombus agrorum *F.* ♂ and ☿; 3. B. cognatus *Steph.*; 4. *B. terrester *L.* ♂; 5. *Melitta (Cilissa) melanura *Nyl.* ♀; 6. Heriades nigricornis *Nyl.* ♂; 7. Melecta luctuosa *Scop.*; 8. *Psithyrus campestris *Pz.*; 9. *P. vestalis *Fourcr.* ♂. **B. Lepidoptera.** (*a*) *Rhopalocera*: 10. Lycaena icarus *Rott.* ♂; 11. Pieris napi *L.* ♂; 12. P. rapae *L.* ♂; 13. Polyommatus dorilis *Hfn.* ♂; 14. Papilio machaon *L.*; 15. Rhodocera rhamni *L.* ♂ and ♀. (*b*) *Noctuidae*: 16. Euclidia glyphica *L.* **C. Diptera.** (*a*) *Muscidae*: 17. Prosena siberita *F.* ♀. (*b*) *Syrphidae*: 18. Helophilus pendulus *L.* ♀; 19. Rhingia campestris *Mg.* ♂; 20. Syritta pipiens *L.*—Of these visitors only the humble-bees regularly effect all the legitimate unions, while the others leave some of the anthers and stigmas untouched, especially those of the long stamens and styles.

1035. L. Hyssopifolia L. (Schulz, 'Beiträge,' I, p. 38.)—The small lilac flowers of this species are arranged in terminal spikes, and Schulz describes them as being slightly protogynous. Since the anthers are at the same level as the stigmas, and very near them, automatic self-pollination regularly takes place, should crossing not be effected by insects, as it sometimes is.

Visitors.—I observed the following in the Kiel Botanic Garden ('Bloemenbiol. Bijdragen').—

A. Hymenoptera. *Apidae*: all skg.; 1. Apis mellifica *L.* ☿; 2. Bombus lapidarius *L.* ☿; 3. B. terrester *L.* ☿. **B. Diptera.** *Syrphidae*: 4. Eristalis tenax *L.*, skg. and po-dvg. **C. Lepidoptera.** *Rhopalocera*: 5. Pieris rapae *L.*, skg.

297. Peplis L.

Very small, inconspicuous, rose-coloured flowers, with exposed nectar.

1036. P. Portula L. (Henslow, Trans. Linn. Soc. (Bot.), London, 2. Ser., 1875, p. 363; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 303–4; Koehne, Bot. Jahrb., Leipzig, vi, 1885, p. 39; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 73.)—In the flowers of this species, according to Koehne, the petals are only 6 mm. long, fugacious, and often absent altogether. The five or six stamens do not project beyond the calyx. The stigma is almost sessile, so that autogamy by the fall of pollen regularly takes place in the tiny blossoms. Submerged flowers remain closed, and, since they contain air, are pseudo-cleistogamously fertilized as the result of automatic self-pollination.

MacLeod describes a small scantily secreting nectary at the base of the ovary. During anthesis the flower is wide open, and its six stamens are curved slightly inwards; but the most anterior and the most posterior stamen, owing to a lateral compression of the flower, do not spread out so much as the other four. Hence it follows that the anthers of these two stamens almost always touch the pistil, so that automatic self-pollination is inevitable. When the flower closes, all six anthers are pressed against the stigma.

According to Willis and Burkill ('Fls. and Insects in Gt. Britain,' I, p. 266), the small inconspicuous sessile flowers are 3 mm. in diameter. The stigma matures a little before the anthers, so that for a time crossing may result from the visits of insects. Automatic self-pollination, however, regularly takes place, for the stamens bend inwards and dust the stigma. All the flowers produce seeds.

VISITORS.—None were observed by Willis and Burkill.

298. Cuphea P. Br.

1037. **C. purpurea** Hort. (=C. procumbens *Orteg.*).—Gaertner describes this species as self-sterile.

1038. **C. micropetala** H. B. et K. (=C. eminens *Planch. et Linden*). (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 235, 346.)—Kerner states that the protandrous flowers of this species have their openings laterally directed. The anthers dehisce on the side which faces upwards away from the stigma; the pollen is therefore likely to be carried away by nectar-sucking insects, and to effect cross-pollination. Some days afterwards, the style, which has increased its length by 11 mm., brings the stigma into the line of access to the nectar, so that insect visitors dusted with pollen must bring about crossing. Failing insect-visits, autogamy takes place by the longest stamen curving up to the stigma, to which it applies its pollen-covered surface.

The obliquely placed ovary bars the way to the nectar secreted in the sacculation at the base of the corolla-tube, leaving only two narrow passages through which pollinating insects have to thrust their proboscis. Creeping insects (ants) are prevented from entering the corolla-tube by adhesive bristles on the margin of the calyx, such forms being useless, or even injurious to the flowers.

299. Punica L.

Odourless and nectarless pollen flowers, bright red in colour; homogamous or protandrous.

1039. **P. Granatum** L. (Schulz, 'Beiträge,' pp. 72–3.)—In this species both calyx and corolla contribute to the conspicuousness of the flower. The former is coral-red, very thick-walled, 26–30 mm. long and 20–25 mm. broad. The brilliantly red, delicate, very fugacious petals are 20–30 mm. long and 10–20 mm. broad. The numerous stamens, the filaments of which are orange-red in colour, are bent inwards, and therefore block the entrance to the flower. The style is very short, and may be either receptive during the dehiscence of the anthers or become so after their pollen is shed. Autogamy by means of pollen that remains in the flower, is possible in both cases.

VISITORS.—Schulz observed (South Tyrol) beetles belonging to the genera Cetonia and Trichodes, dvg. the flowers, and often effecting cross- as well as self-pollination.

XLII. ORDER *ONAGRARIEAE* JUSS.

300. Epilobium L.

Flowers red, more rarely white, frequently arranged in large conspicuous racemose inflorescences; protandrous, homogamous, or protogynous; with concealed nectar secreted by the upper surface of the ovary. The pollen-grains are usually bound together by threads of viscin.

1040. E. angustifolium L. (=E. spicatum *Lam.*, and Chamaenerion angustifolium *Scop.*). (Sprengel, 'Entd. Geh.'; Herm. Müller, 'Fertilisation,' pp. 261–2, 'Weit. Beob.,' II, p. 237; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Warming, 'Bestövningsmaade af nogle grönlandsk. Blomster,' pp. 32–3; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 291–2; Kerner, Nat. Hist. Pl.,' Eng. Ed. 1, II; Schulz, 'Beiträge,' II, p. 73; Knuth, 'Bloemenbiol. Bijdragen'; Loew, 'Blütenbiol. Floristik,' p. 394.)—Kerner says that the purple-red, rarely white flowers of this species, open between 6 and 7 a.m., and are protandrous to an extent that precludes self-pollination, as Sprengel long ago observed. The nectar secreted by the fleshy green top of the ovary is protected from rain, for the expanded bases of the filaments converge to form a hollow cone, which grasps the base of the style. Where the style leaves the cone it is covered with hairs which prevent rain-drops from entering, while the proboscis of an insect can easily be pushed through to the nectar.

In younger flowers, the stamens (which are covered with pollen-grains bound together by threads of viscin) serve as the only possible alighting-place for insects, for the style is still short, and the stigmas apposed. In older flowers the dehisced stamens curve downwards, while the now elongated style with its four diverging recurved stigmas forms the only alighting-place, so that insects coming from younger flowers must pollinate older ones.

The flower mechanism does not always conform to the above description. Warming states that the var. *leiostyla* is slightly protogynous along the Isortokfjord, and therefore capable of self-pollination. According to Schulz, the flowers in the lowlands are more distinctly protandrous than in the mountains (Tyrol), where the stigmas are mature in some cases before the pollen is entirely shed. Kerner says that the style, short at first, elongates after twenty-four hours, and the widely diverging stigmas finally recurve so as to touch the pollen-covered anthers: hence automatic self-pollination can be effected. Kerner found plants with normal flowers in only a few places. In shady localities the flowers dry up and fall off; an attempt is also made to overcome the disadvantages of unfavourable habitats of this kind by the development of long runners.

VISITORS.—Sprengel observed various humble-bees. I myself noticed 5 nect-skg. bees.—

1. Apis mellifica *L.* ☿; 2. Bombus agrorum *F.* ♀; 3. B. hortorum *L.* ♀ and ☿; 4. B. lapidarius *L.* ♀, ☿ and ♂; 5. B. terrester *L.* ♀ and ☿.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list —

A. Coleoptera. *Cerambycidae*: 1. Strangalia melanura *L.*, nect-lkg. (H. M.). **B. Diptera.** (*a*) *Empidae*: 2. Empis livida *L.*, freq., skg. (H. M.); 3. E. rustica *Fall.*, do. (H. M.). (*b*) *Stratiomyidae*: 4. Chrysomyia polita *L.*, skg. (Budd.).

(*c*) *Syrphidae*: 5. Syrphus ribesii *L.*, po-dvg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 6. Apis mellifica *L.* ☿, exceedingly common, skg. and po-cltg. (H. M.); 7. Bombus agrorum *F.* ♀, ☿ and ♂, very common, skg. (H. M.); 8. B. confusus *Schenck* ♀, freq., skg. (H. M.); 9. B. lapidarius *L.* ♀ and ☿, do. (H. M.); 10. B. pratorum *L.* ♀, ☿ and ♂, do. (H. M.); 11. B. terrester *L.* ♀, ☿ and ♂, do. (H. M); 12. Halictus flavipes *F.* ♀, skg. (Budd.); 13. H. malachurus *K.* ♀, do. (Budd.); 14. H. nitidus *Schenck* ♀, do. (Budd.); 15. Megachile versicolor *Sm.* ♀, do. (H. M., Thuringia); 16. Nomada jacobaeae *Pz.* ♀ (H. M.); 17. N. roberjeotiana *Pz.* ♀, skg. (H. M.); 18. Psithyrus campestris *Pz.* ♂, skg. (H. M.); 19. Sphecodes gibbus *L.* ♀, do. (H. M.). (*b*) *Sphegidae*: 20. Ammophila sabulosa *L.*, skg. (H. M.); 21. Cerceris labiata *F.*, do. (H. M.); 22. Crabro alatus *Pz.*, do. (H. M.); 23. C. cribrarius *L.* ♂, do. (H. M.). (*c*) *Tenthredinidae*: 24. Allantus scrophulariae *L.*, skg. (H. M.). **D. Lepidoptera.** 25. Ino statices *L.*, do. (H. M.); 26. Zyganea filipendulae *L.* do. (H. M.).

Loew observed the following.—

(*a*) In the Berlin Botanic Garden, the bees—1. Apis mellifica *L.* ☿, skg.; 2, Bombus rajellus *K.* ♂, do.; 3. Chelostoma nigricorne *Nyl.* ♂, do. (*b*) In the Riesengebirge, the humble-bee Bombus agrorum *F.* ☿, skg. (*c*) In Silesia, the butterfly Hesperia comma *L.*

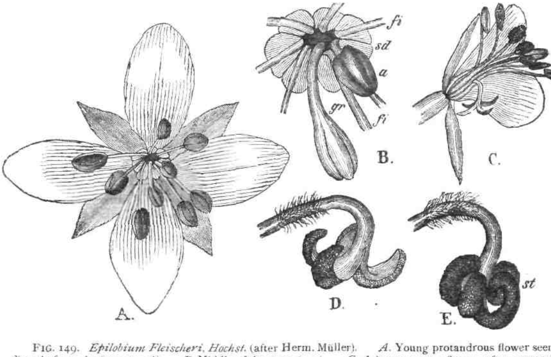


FIG. 149. *Epilobium Fleischeri, Hochst.* (after Herm. Müller). *A.* Young protandrous flower seen directly from the front (× 2⅓). *B.* Middle of the same (× 7). *C.* A homogamous flower, after removal of a sepal and two petals (× 2⅓). *D.* Style of a protogynous flower, in which an anther is beginning to dehisce (× 7). *E.* Style of a flower, on the anthers of which a small quantity of pollen still remains (× 7). *a*, anther; *fi*, filament; *gr*, style; *sd*, nectar-cover; *st.* stigma.

The following were observed by the authorities, and in the localities stated.—

Alfken (Bremen) the bees—1. Bombus agrorum *F.*; 2. B. arenicola *Ths.*; 3. B. derhamellus *K.*; 4. B. distinguendus *Mor.*; 5. B. jonellus *K.*; 6. B. lapidarius *L.*; 7. B. proteus *Gerst.* ♀; 8. B. terrester *L.*; 9. Halictus calceatus *Scop.* ♀; 10. Macropis labiata *F.* ♀ and ♂; 11. Megachile centuncularis *L.* ♂; 12. Podalirius furcatus *Pz.* ♂. Verhoeff (Norderney) the Capsid Calocoris chenopodii *Fall.* ♀ and ♂. Krieger (Leipzig) the bees—1. Bombus agrorum *F.* ♂; 2. Eriades nigricornis *Nyl.*; 3. Halictus smeathmanellus *K.*; 4. Prosopis confusa *Nyl.* Hoffer (Steiermark) the bees—1. Bombus distinguendus *Mor.* ♂; 2. B. hypnorum *L.* ☿; 3. Psithyrus vestalis *Fourcr.* ♂. Redtenbacher (Vienna) the Chrysomelid Adoxus obscurus *L.* Schmiedeknecht the bees—1. Andrena fumipennis *Schmiedekn.*; 2. Bombus distinguendus

Mor. ♂; 3. B. hypnorum *L.* ♂; 4. B. jonellus *K.* ♂; 5. B. mastrucatus *Gerst.* ♂; 6. B. pratorum *L.* ♂; 7. B. soroënsis *F.* ♂; 8. B. terrester *L.* ♂; 9. Psithyrus vestalis *Fourcr.* ♂. Frey-Gessner (Switzerland) the humble-bees Bombus pratorum *L.* ♀, ☿ and ♂, and B. scrimshiranus *K.* (=B. jonellus *K.*) ♂. Herm. Müller (Alps) a beetle, 5 flies, 11 Hymenoptera, and a Lepidopterid ('Alpenblumen,' p. 209). Scott-Elliot (Dumfriesshire) 2 humble-bees and a wasp, both freq. ('Flora of Dumfriesshire,' p. 64).

1041. **E. Dodonaei** (=E. rosmarinifolium *Haenke*, and E. angustissimum *Weber*). (Schulz, 'Beiträge,' II, p. 73.)—Schulz says that the flowers of this species usually display well-marked protandry, for the four stigmas only spread out when the anthers have lost all their pollen. Sometimes, however, they begin to do so before the pollen is entirely shed, and automatic self-pollination is then possible.

Visitors.—Schulz observed nect-skg. and po-cltg. bees, skg. Lepidoptera, and po-dvg. Diptera.

Herm. Müller noticed 4 bees and 2 Lepidoptera in the Alps ('Alpenblumen,' p. 211). Loew saw Apis, skg., in the Berlin Botanic Garden.

1042. **E. Fleischeri** Hochst. (=E. denticulatum *Ulend.*). (Herm. Müller, 'Fertilisation,' p. 262, 'Alpenblumen,' pp. 209–11.)—The flowers of this species agree in many respects as regard mechanism with those of E. angustifolium, but may be protandrous, homogamous, or protogynous. In all three cases, however, crossing is favoured by the fact that either the diverging stigmatic branches or the stamens serve as the most convenient alighting-place. Automatic self-pollination always takes place should insect-visits fail.

Visitors.—Herm. Müller observed a Syrphid, 13 bees, 2 fossorial wasps, and 4 Lepidoptera. Loew noticed a Syrphid (Syrphus balteatus *Deg.*) and a bee (Halictus minutissimus *K.* ♀) in the Berlin Botanic Garden.

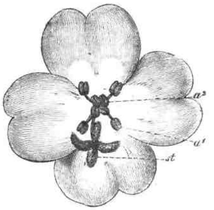


FIG. 150. *Epilobium hirsutum*, *L.* (after Herm. Müller). Flower seen directly from above. a^1 and a^2, anthers of long and short stamens; *st*, stigma.

1043. **E. hirsutum** L. (=E. grandiflorum *Weber*). (Herm. Müller, 'Fertilisation,' pp. 263–4; Schulz, 'Beiträge,' I, pp. 35–6.)—The mechanism of the large, dark-purple flowers of this species varies in different localities, while Hermann Müller recognized only homogamous flowers 25–30 mm. in diameter. Schulz describes three forms borne on different stocks.—1. *Large*: these are zygomorphous and markedly protandrous, with long styles curved in such a way that self-pollination is prevented. 2. *Medium*: these are rarer (at Halle and in North Thuringia) than the previous kind. They are less distinctly zygomorphous, and are usually slightly protandrous, rarely almost homogamous. The style is straight; and should insect-visits fail the stigmas curve back in such a way as to touch the anthers of the longest stamens, so that self-pollination is possible. 3. *Small*: these are still smaller than the medium ones, and homogamous. As the stigmas are at the same level as the longest stamens, automatic self-pollination is inevitable.

Besides the hermaphrodite stocks there are some female ones. Their flowers possess stamens, but the anthers do not dehisce. Schulz observed gynomonoecism, more rarely gynodioecism.

Kerner says that the flower mechanism does not differ essentially from that of E. angustifolium.

VISITORS.—I observed the following at Glücksburg ('Bloemenbiol. Bijdragen').—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, very freq., skg. and po-cltg.; 3. Bombus agrorum *F.* ♀, skg. and po-cltg.; 4. B. sylvarum *L.* ♀, do.; 5. B. terrester *L.* ♀, do. **C. Lepidoptera.** 6. Pieris sp., freq., skg.

MacLeod saw Apis, a Syrphid, a Muscid, and a Lepidopterid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 294, 380).

In Dumfriesshire, a humble-bee and a short-tongued bee were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 69).

1044. E. parviflorum Schreb. (Schulz, 'Beiträge,' I, pp. 36–7; Herm. Müller, 'Fertilisation,' pp. 262–3.)—In this species again, according to Schulz, the length of the stamens and style varies, as does their order of development. In most cases the anthers are at the same level as the end of the style, or even project beyond it, so that, the flowers being homogamous, automatic self-pollination is inevitable. More rarely the style projects beyond the anthers, and sometimes the stigmas mature a little before they dehisce, but the flowers are often homogamous. Here again self-pollination frequently takes place. It may be effected, according to Kerner, as early as the first day of anthesis.

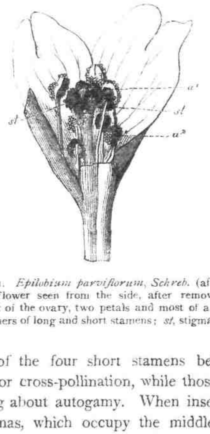


FIG. 151. *Epilobium parviflorum, Schreb.* (after Herm. Müller). Flower seen from the side, after removal of the greater part of the ovary, two petals and most of a sepal. a^1 and a^2, anthers of long and short stamens; *st*, stigma.

Hermann Müller states that the flowers are homogamous, the anthers of the four short stamens being at a lower level than the stigmas, and serving for cross-pollination, while those of the four long ones are at the same level and bring about autogamy. When insects visit the flowers, they usually first touch the stigmas, which occupy the middle of the flower, and therefore usually effect cross-pollination. (*Cf.* Fig. 151.)

The rather small pale-red flowers are solitary, and do not receive many visits.

VISITORS.—I have only observed the honey-bee, skg. and po-cltg. Herm. Müller only noticed the beetle Meligethes, and a butterfly (Pieris rapae *L.*, freq., skg.). MacLeod saw Pieris sp. in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 298).

1045. E. montanum L. (Schulz, 'Beiträge,' I, p. 37.)—Schulz describes the flowers of this species as homogamous. Since the anthers of the long stamens

are usually on a level with the stigmas, autogamy is the rule, and Kerner says it may take place as early as the first day of anthesis. It is excluded in flowers where the long stamens do not reach the stigmas.

VISITORS.—These are few. Herm. Müller observed flies (Anthomyia ♀, po-cltg.), and a butterfly (Pieris napi *L.*, skg.) ('Weit. Beob.,' II, p. 237).

Schletterer records the humble-bee Bombus pomorum for the Tyrol. MacLeod saw a hover-fly and a beetle in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 298).

In Dumfriesshire, 2 Muscids and 2 Syrphids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 65).

1046. E. collinum C. C. Gmel.—In this species again, according to Kerner, automatic self-pollination may take place on the first day of anthesis, the stamens being long enough for the anthers to touch the stigmas.

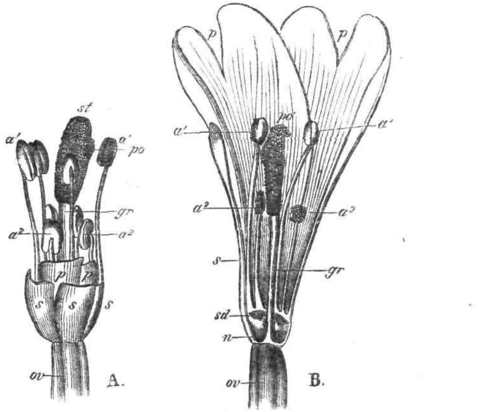


FIG. 152. *Epilobium alsinifolium*, *Vill.* (after Herm. Müller). *A.* Young flower, shortly after opening: the upper parts of the sepals and petals have been removed. *B.* Older flower, after removal of two sepals and petals (× 7). *a*¹ and *a*², anthers of long and short stamens; *gr*, style; *n*, nectar; *ov*, ovary; *p*, petal; *po*, pollen; *s*, sepal; *sd*, nectar-cover; *st*, stigma.

VISITORS.—Herm. Müller saw 2 short-tongued bees in the Alps ('Alpenblumen,' p. 213).

1047. E. roseum Retz.—Schulz says that automatic self-pollination is usually inevitable in the homogamous flowers of this species, the anthers of the long stamens reaching the level of the non-divergent stigmas and coming into contact with them.

VISITORS.—MacLeod saw the butterfly Pieris napi *L.* in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 296).

In Dumfriesshire, 2 hover-flies and a Lepidopterid were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 66).

1048. **E. alpinum** L. (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' pp. 18, 109.)—Axell states that the flowers of this species are autocarpous as the result of automatic self-pollination, should insect-visits fail. Warming describes plants brought from Greenland and cultivated in Copenhagen as extremely fertile after automatic self-pollination.

1049. **E. alsinifolium** Vill. (=E. origanifolium *Lam.*). (Herm. Müller, 'Fertilisation,' p. 263, 'Alpenblumen,' pp. 211–13; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Schulz, 'Beiträge,' I, p. 37.)—The flowers of this species are always capable of automatic self-pollination in the Alps, but being slightly protogynous may also be cross-pollinated if visited early by insects. The flower mechanism is the same in the Scandinavian Highlands, but, according to Lindman, the flowers are homogamous there. Schulz found them to be slightly protogynous in the Riesengebirge, and also adapted for automatic self-pollination, the anthers being applied closely to the stigmas. Owing to the tubular form of the flower, the nectar is especially accessible to Lepidoptera, though a proboscis of 6–7 mm. long is required to reach it.

Visitors.—Herm. Müller saw a butterfly (Argynnis) and a hover-fly (Syrphus).

1050. **E. adnatum** Griseb. (=E. tetragonum *L.*). (MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 296–7.)—This species was studied during very hot weather (2. 7. '94), and the three following stages made out in the development of the flowers.—

1. In the still closed flower, the tips of the petals project about 0·25 mm. beyond the calyx. The four long (antisepalous) stamens reach half-way up the style, and their anthers have already shed most of their pollen-grains. These are loosely united into tetrads, and indeed some of them have already sent out pollen-tubes into the pistil. The anthers of two of the four short (antipetalous) stamens are beginning to dehisce.

2. The petals now project 2 mm. from the bud. The four short stamens have elongated and discharged most of their pollen upon the lower part of the style. Many pollen-grains have sent out long tubes into the pistil. There is a considerable quantity of nectar in the base of the flower.

3. The flower is quite open. The four long stamens have elongated to such an extent that their anthers project beyond the style, while the four short ones are half its length. All the anthers are brown and empty, and the style is brownish in colour; indeed it usually begins to assume this hue in the bud. The flower closes towards the end of anthesis, and the anthers are pressed against the style.

When the weather is not so warm, the development of the reproductive organs appears to be retarded. In any case automatic self-pollination is inevitable; crossing, though not impossible, is very unlikely to take place.

Visitors.—None have so far been observed.

1051. **E. roseum** Schreb. (MacLeod, op. cit., vi, 1894, pp. 295–6.)—When anthesis begins in this species the eight anthers have already dehisced, those of

the four long (antisepalous) stamens being (in some flowers) at the same level as, but remote from, the stigmas, which by this time have become receptive. The anthers of the four short stamens are $\frac{1}{2}$–1 mm. below the stigmas, though not so far away from them as the others. Automatic self-pollination is therefore impossible. Insects can effect cross- and self-pollination with equal facility.

In other flowers, the anthers of the four long stamens cling to the style after discharging their pollen. The filaments elongate later on, and, as the anthers are not set free from the style, are subjected to a stress which forces them to bend inwards. They sometimes remain in this condition till the end of anthesis, so that crossing by insects is almost impossible. In other cases they gradually free themselves from the style, on which the greater part of the pollen is left behind. When the flower closes the anthers are pressed against the stigmas, so that autogamy is inevitable.

VISITORS.—MacLeod saw the butterfly Pieris napi *L.*, skg.

1052. **E. latifolium** L. (Warming, 'Bestövningsmaade af nogle grönlandsk. Blomster,' p. 143.)—This species is native to high northern latitudes. Warming states that the large flowers vary from slightly protandrous to slightly protogynous. The remarkably short style is bent down, bringing the stigmas below the anthers, so that autogamy may result from the fall of pollen. Should this take place, however, it does not result in autocarpy. There is a large amount of vegetative reproduction by means of offsets.

Several sub-species have been found in Greenland, where blossoms of pure white colour are rare. Vanhöffen states that as a rule the flowers are feebly protandrous, but two stocks bearing strongly protandrous ones were observed (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 13).

There would appear to be insect visitors in Greenland, for a hybrid (=E. ambiguum *Fries*) has been found at Disko between this species and E. angustifolium.

1053. **E. lactifolium** Haussk. (Abromeit, op. cit., pp. 12–13.)—This arctic species ranges south to Scandinavia and Lapland. It bears small whitish flowers, and reproduces vegetatively by means of short offsets arranged in a rosette-like manner. It has been observed in Greenland by Vanhöffen and K. Rosenvinge.

301. Lopezia Cav.

Flowers markedly protandrous, often with an explosive stamen.

According to Delpino ('Ult. oss.,' II, pp. 124–6), there are two pseudonectaries at the knee-like bend of the two upper petals. These shine like drops of nectar, but are dry in reality (*cf.* Parnassia, p. 413). The true secreting nectary is at the base of the two stamens, of which one is sterile and specialized. (*Vide infra.*)

1054. **L. coronata** Andr. (Hildebrand, Bot. Ztg., Leipzig, xxiv, 1866, p. 76.)—One of the original two stamens in this species is modified into a stalked spoon-shaped staminode, the two halves of which at first surround the anther of the normal stamen, and project horizontally from the flower. As the stalk of the spoon is

in a state of downward and the filament in a state of upward tension, an insect alighting upon the staminode in order to reach the pseudo-nectaries (*vide supra*), will cause these opposed strains to become effective. The spoon will suddenly bend downwards, while the stamen immediately above it will explode upwards, at the same time applying its pollen to the under-side of the visitor's body. The stamen afterwards bends out of the flower, while the style goes on growing, and projects from the flower to serve as an alighting-place. Automatic self-pollination is excluded.

VISITORS.—Herm. Müller frequently observed the house-fly (Musca domestica *L.*) and the common gnat (Culex pipiens *L.*) effect pollination in his room, and the honey-bee do so at an open window ('Fertilisation,' p. 265).

1055. **L. racemosa** Cav.—According to Ogle's account (Pop. Sci. Rev., London, viii, 1869, p. 271), the flower mechanism of this species is the same as that of L. coronata.

1056. **L. miniata** DC. (Hildebrand, op. cit., xxiv, 1866, pp. 478–9.)—In this species the fertile stamen is not explosive, and lies above the spoon-shaped staminode.

302. **Oenothera** L.

Protandrous lepidopterid flowers. Honey is secreted by and concealed in the base of the calyx-tube. Kerner states that the peduncle is curved so as to make the entrance to the flower lateral. He also describes the pollen-grains as being bound together by threads of viscin. Many of the species are night flowerers (*vide infra*).

1057. **O. biennis** L. (Sprengel, 'Entd. Geh.,' pp. 217–23; Herm. Müller, 'Fertilisation,' p. 264; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. I. II; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 151, 'Bloemenbiol. Bijdragen.')—Sprengel long ago thoroughly described the flower mechanism of this species, which is native to Virginia. The large bright yellow flowers are devoid of nectar-guides. They open in the evening, and are then most fragrant, and would therefore appear to be especially adapted to crepuscular and nocturnal Lepidoptera. They are, however, owing to their bright yellow petals, also conspicuous during the day, when they are visited by long-tongued bees, and must consequently be placed in the transition class, **LmH.** The secretion of the smooth, yellow nectary in the base of the calyx-tube is protected by fine woolly hairs. It flows into the upper naked part of the tube, and adheres to the style, which is here pressed against the lower wall of the tube. The individual flowers remain in bloom for two nights. Kerner says that they open shortly before 6 p.m., and close twenty-four hours later. When the flower opens, the anthers shed their pollen, but at this stage the four stigmas are still apposed. On the morning of the second day the stigmas begin to diverge, and are fully developed the second night, while the stamens are now shrivelled. Kerner says that the edge of the corolla does not serve as an alighting-place for insect visitors, but is only attractive. When a visitor inserts its proboscis into a flower, it touches the anthers with its head, and at the beginning of anthesis the stigmas, owing to a lateral curvature of the style, are out of the line of access to the nectar. But, according to Kerner's account, the style straightens half an hour later, and the stigmas spread out, so that crossing may be effected by insects

already dusted with pollen. As the four stigmas roll back so as ultimately to touch the anthers before these have lost all their pollen, autogamy takes place if insect-visits fail.

VISITORS.—On the North Frisian Islands I only noticed po-cltg. or po-dvg. insects (Apis, Bombus terrester *L.*, Eristalis, Scatophaga). I also observed skg. insects at Kiel, i.e. Macroglossa stellatarum *L.* (in the dusk), and Bombus hortorum *L.* ♀ (in the forenoon). Loew saw Apis, po-cltg., in the Berlin Botanic Garden.

Herm. Müller gives the following list.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, very freq., po-dvg.; 2. E. nemorum *L.*, do.; 3. E. tenax *L.*, do. **B. Hymenoptera.** *Apidae*: 4. Apis mellifica *L.* ☿, skg. and po-cltg.; 5. Bombus agrorum *F.* ♀, skg.; 6. B. lapidarius *L.* ♀, do.; 7. B. sylvarum *L.* ♀, do.; 8. Colletes daviesanus *K.* ♀, po-cltg.; 9. Panurgus calcaratus *Scop.* ♀ and ♂. **C. Lepidoptera.** *Sphingidae*: 10. Macroglossa stellatarum *L.*, skg.

Redtenbacher records the Elaterid Corymbites sulphuripennis *Germ.* for Austria.

1058. O. muricata L. (=O. biennis *L.*, according to the *Index Kewensis*).—Kerner states that the flower mechanism in this North American species agrees with that of O. biennis.

1059. O. biennis L., × **O. muricata** L.—

VISITORS.—Heinsius saw the following in Holland (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, p. 115).—

Three humble-bees, skg. and effecting pollination (Bombus cognatus *Steph.* ♀; B. hortorum *L.* ♀, ♂ and ☿; B. rajellus *K.* ♀). A small bee (Halictus leucozonius *Schr.* ♂) skg., and occasionally effecting pollination. Empids (Empis hyalipennis *Fall.* ♂ and ♀; E. pennaria *Fall.* ♀) and a Syrphid (Eristalis nemorum *L.* ♂), do.

1060. O. Lamarkiana Ser. (=O. biennis *L.*, according to the *Index Kewensis*). (Stadler, 'Beiträge zur Kennt. de Nekt. u. Biol. d. Bl.,' Berlin, 1886.)—The flower mechanism of this species agrees with that of O. biennis. The very fragrant Lepidopterid flowers are protandrous. Stadler says that the nectary lines the base of the corolla-tube, and, like the inner surface of two-thirds of the tube, is beset with unicellular barrier-hairs. The upper part of the tube is lined with a felting of hairs. Nectar is secreted so abundantly that it usually ascends to a height of 5 mm. The pollen-grains are bound together by threads of viscin, and remain hanging between the anthers. Self-pollination is rendered impossible by this peculiar fixing arrangement. Each pollen-grain has rounded poles, from which two or more small bunches of threads project. These interweave with those of neighbouring grains, and thus the pollen, 'entangled as in a spider's web into strings and clumps,' remains on or between the anthers, and cannot be scattered by the wind nor by the action of gravity.

VISITORS.—Heinsius observed the following in Holland (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, pp. 113–15).—

Four humble-bees, skg. (Bombus agrorum *F.* ♀ and ☿; B. cognatus *Steph.*; B. hortorum *L.* ☿: B. lapidarius *L.* ♀ and ☿), and 3 hover-flies, po-dvg. (Eristalis horticola *L.* ♀; E. intricarius *L.* ♀; Pelecocera tricincta *Mg.* ♂).

1061. O. missouriensis Sims. (Knuth, 'Bloemenbiol. Bijdragen.') — The North American species cultivated under this name in our gardens bears moth

flowers. They exhale a strong odour of citrons in the evening, but are odourless during the day. The calyx-tube is more than 10 cm. long, so that none of our native hawk-moths possess a proboscis long enough to reach the bottom of it. Even the proboscis of Sphinx convolvuli *L.* only exceptionally attains a length of 8 cm. The flowers are homogamous. The four stigmas project about 15 mm. beyond the tip of the anthers, so that alighting insects first touch the former and then the latter, thus constantly effecting cross-pollination.

VISITORS.—Hitchcock records the hawk-moth Deilephila lineata *F.* (Bull. Torrey Bot. Cl., New York, xx, 1893, p. 362).

1062. O. grandiflora Ait.—Kerner states that this North American species bears night flowers (*cf.* O. biennis, p. 448). When they open the petals rapidly separate, and spread out in half an hour.

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A Chrysomelid (Haltica oleracea *L.*) resting in the mouth of the corolla-tube, and a bee (Apis mellifica *L.* ☿), po-cltg., loading itself with long threads of pollen, which hung down from its legs and impeded flight.

1063. O. speciosa Nutt.—The beautifully fragrant Lepidopterid flowers of this species are white in colour, turning red when they are over. Wolfensberger (Mitt. Schweiz. Entomol. Ges., Schaffhausen, vii, 1884, pp. 5–7) states that various hawk-moths (Deilephila elpenor *L.*, D. porcellus *L.*) are captured by them, the proboscis being held fast by inwardly directed barrier-hairs lining the corolla-tube. But Glaser (Ent. Nachr., Berlin, xiv, 1888, pp. 53–5) found (at Mannheim) that hawk-moths went to sleep with the proboscis sunk in the flowers, thus giving the appearance of captivity. He denies the existence of arrangements able to hold fast the proboscis.

1064. O. Simsiana Ser. (Willkomm, 'Nachtbl. u. ihr Leben.')—This Mexican species bears night flowers.

VISITORS.—The flowers are pollinated by beetles in the Prague Botanic Garden.

303. Godetia Spach.

1065. G. Lindleyana Spach.—Comes describes this species as protandrous and self-fertile ('Ult. stud.').

1066. G. Cavanillesii Spach.—This species is native to Central Chili. Philippi (Bot. Ztg., Leipzig, xxviii, 1870, pp. 104–6) says that it produces cleistogamous flowers in spring.

304. Circaea Tourn.

Homogamous hover-fly flowers, in the bases of which nectar is secreted.

1067. C. lutetiana L. (Herm. Müller, 'Fertilisation,' pp. 265–7.)—The small flowers of this species are white, often with a reddish tinge, and are arranged in loose racemes. Hermann Müller describes the flower mechanism as being very similar to that of Veronica Chamaedrys (vol. I, p. 136). The two stamens project one on either side from the vertically pendulous flower. Between them is the style,

which projects rather further from the flower, and bears a terminal capitate stigma. These three organs serve as alighting-rods, by which an insect must support itself while getting at the nectar, which is secreted in the base of the flower by a ring surrounding the beginning of the style. As the latter is somewhat lower and longer than the stamens, insect visitors mostly alight upon it, and will effect crossing if they are dusted with pollen from another flower. They apply this to the bilobed stigma with the under-side of their body. The visitor next proceeds to get nearer the nectar, using its fore-legs to seize the stamens by their thin easily yielding bases, and pulling them inwards and downwards. The dehiscing anthers are thus brought into contact with the under-side of the body, dusting it anew with pollen.

An insect not infrequently alights upon one of the two stamens. As this bends downwards from the weight, its base and the style are at once seized by the fore-legs. In this way the stigma is usually brought into contact with the under-side of the visitor, and crossing results if a visit has previously been paid to another flower, for the stigma and anther touch opposite sides of the body.

If insect-visits fail, automatic self-pollination is usually excluded, for it but rarely happens that the anthers and stigma come into direct contact when the flower fades.

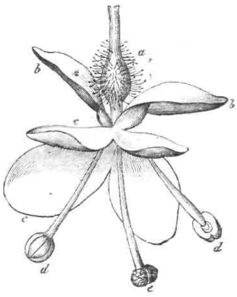


FIG. 153. *Circaea lutetiana*, *L.* (after Herm. Müller). Flower seen obliquely from above. *a*, ovary; *b*, sepal; *c*, petal; *d*, stamen; *e*, stigma.

VISITORS.—These are exclusively Diptera, especially Syrphids. I observed the following, all skg. and po-dvg.—

(*a*) *Muscidae*: 1. Lucilia cornicina *F.*; 2. Musca domestica *L.*; 3. Scatophaga stercoraria *L.* (*b*) *Syrphidae*: 4. Ascia podagrica *F.*; 5. Eristalis nemorum *L.*; 6. Melanostoma mellina *L.*; 7. Syrphus sp.

Herm. Müller gives a similar list.—

(*a*) *Muscidae*: 1. Anthomyia sp.; 2. Musca domestica *L.* (*b*) *Syrphidae*: 3. Ascia podagrica *F.*; 4. Bacha elongata *F.*; 5. Melanostoma mellina *L.*

MacLeod saw an Andrena and a hover-fly in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 299).

In Dumfriesshire, a hover-fly was recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 67).

1068. C. alpina L.—The flower mechanism is the same as that of the last species. Kerner states that automatic self-pollination takes place towards the end of anthesis, one or both anthers being applied to the stigma.

VISITORS.—These are again chiefly hover-flies, which behave as described for the last species. I observed the medium-sized forms Melanostoma mellina *L.* and Eristalis sp.

1069. **C. intermedia** Ehrh.—

VISITORS.—These are the same hover-flies as in C. alpina. This lends support to the view that this species is a hybrid between C. lutetiana and C. alpina which has become fixed. Loew saw Thrips in the Berlin Botanic Garden.

305. Isnardia L.

1070. **I. palustris** L. (=Ludwigia palustris *L.*).—In this species, according to Vaucher ('Hist. physiolog. des pl. d'Europe,' II, p. 338), the anthers of the green inconspicuous flowers are inclined towards the stigma at the beginning of anthesis, and the shrivelled anthers together with the style soon fall off. Monoecious stocks also occur (var. *paludosa* Rabenhorst).

306. Gaura L.

1071. **G. biennis** L.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus ribesii *L.*, po-dvg. **B. Hymenoptera.** (*a*) *Apidae*: 2. Apis mellifica *L.* ☿, po-cltg. (*b*) *Vespidae*: 3. Odynerus parietum *L.*, var. renimacula *Lep.* ♀.

307. Fuchsia L.

1072. **F.** sp.—Gaertner states that the species of Fuchsia are self-fertile.—

VISITORS.—Schneider records the humble-bees Bombus pratorum *L.* ☿ and B. terrester *L.* ☿ for gardens in Arctic Norway (Mus. Aars. Tromsø, 1894).

308. Trapa L.

Small inconspicuous whitish flowers. Caspary describes the nectary as a glandular ring surrounding the middle of the ovary ('De nectariis').

1073. **T. natans** L.—For plants of this species living in Lake Maggiore Gibelli and Buscalioni determined that anthesis extends from the end of June to the beginning of September, reaching its maximum in August. The flowers normally expand an hour or half an hour before sunrise, and remain open only a few hours. On warm and dry days the peduncles begin to curve carpotropically after 5–6 hours; on dull cloudy days this takes place later. The flowers almost always open in the air, rarely under water. Some of the closed submerged ones possess dehisced anthers and pollen-covered stigmas, so that they must be described as hydro-cleistogamous. Usually, however, these flowers open if the plant is taken out of the water. Such opening is effected by the elongating stamens, which press against the petals, and push them apart. The higher temperature of the air also helps to bring this about. After the flowers have opened in the air autogamy usually follows.

VISITORS.—Gibelli advanced the view in 1891 that pollination is presumably effected by the larvae of the water-bug Mesovelia furcata *Muls et Rey*, but he and Buscalioni subsequently (1893) came to the conclusion that the presence of the larvae in the flowers is merely accidental, for these little creatures are not in the smallest degree adapted to the mechanism. Nor did these observers regard

the weevils occasionally met with in the flowers as regular agents of pollination, though they might sometimes bring this about.

1074. **T. verbanensis** De Not. Cat. Sem. Ort. Bot. Roma (1875).—The flowers of this species possess the same mechanism as T. natans.

XLIII. ORDER *LOASEAE* JUSS.

309. Caiophora Presl.

1075. **C. lateritia** Benth. (Delpino, 'Altri appar. dicog. recent. oss.')—Delpino describes the flowers of this species as markedly protandrous. In the first stage of anthesis the five anthers open in succession, and occupy the middle of the flower; they afterwards bend back towards the petals. In the second stage the stigma matures, and occupies the position previously taken up by the anthers.

VISITORS.—*These appear to be bees.*

XLIV. ORDER *TURNERACEAE* H. B. et K.

Urban states that about eight-ninths of all the known species of this order are dimorphously heterostylous (Verh. bot. Ver., Berlin, xxiv, 1882).

XLV. ORDER *PASSIFLOREAE* JUSS.
(including PAPAYACEAE Juss.)

310. Passiflora L.

Protandrous, humble-bee (and humming-bird) flowers; with nectar secreted by a fleshy ring in the base of the calyx, and protected by three nectar-covers.

1076. **P. caerulea** L. (Sprengel, 'Entd. Geh.,' pp. 160–5; Herm. Müller, 'Fertilisation,' pp. 267–8; Warnstorf, Schr. natw. Ver., Wernigerode, xi, 1896, pp. 3–4.)—The beautiful flowers of this species are large and very conspicuous. The petals are white, and so is the inner surface of the calyx. There are differently coloured concentric rings which serve as nectar-guides. They consist of a large outer circlet of rays, a small inner one, and the outer nectar-cover. As the nectar reservoir possesses but one ring-like aperture, visitors must go right round the reservoir to get all the nectar. Larger insects only can effect crossing, and it is easy for them to go round owing to the large outer circlet of rays; they move from ray to ray as if on the spokes of a wheel, thrusting their proboscis into the reservoir as they do so.

In the first stage of anthesis, a large insect (such as a humble-bee) when sucking the nectar, receives pollen on its back from the downwardly dehiscing anthers. In the second stage the styles have curved downwards to such an extent that the now receptive stigmas are lower than the empty anthers. It follows that older flowers are fertilized by pollen from younger ones.

Warnstorf gives a similar account.—Anthesis lasts one day. When the bud opens the five anthers have already dehisced and are directed outwards, in line with the thick stiff filaments. As the flower fully expands, each anther rotates through an angle of 180° in the vertical plane of its filament, so as to bring its

pollen-covered lobes towards the interior of the flower. There is next a second rotation of 90° into a horizontal plane cutting the first at right angles, so that the anther finally comes to be at right angles to the tip of its filament with its dehisced surface facing downwards. The three purple-flecked styles with their green capitate stigmas curve upwards, and project about 10 mm. beyond the anthers. Autogamy would seem to be excluded under such circumstances, yet it is possible that the stigmas and anthers may be brought into contact when the flower closes at the end of the single day's anthesis. This is the more probable as Warnstorf saw a fully formed fruit in a greenhouse. Here then, there is apparently a case in which an obviously chasmogamous flower is only self-pollinated after it has closed. The pollen-grains are golden-yellow in colour, adhesive, conico-tetrahedral, with low anastomosing ridges or folds, 63–75 μ in diameter.

VISITORS.—Delpino has observed humble-bees and the carpenter bee Xylocopa violacea ('Sugli appar. d. fecondaz. nelle piante autocarp.,' p. 31; Hildebrand, Bot. Ztg., Leipzig, xxv, 1867, p. 284).

1077. P. princeps Lodd. (=P. racemosa *Brot.*).—According to Delpino ('Ult. oss.,' pp. 170, 172), the corolla-tube is divided into three chambers by circlets of rays, the lowest containing the nectar, which only discriminating visitors can reach.

VISITORS.—Delpino supposes these to be humming-birds. Fritz Müller (Herm. Müller, 'Fertilisation,' p. 268) actually observed them in Brazil on flowers of species of Passiflora. He is of opinion that the latticed work in the upper part of the corolla-tube is not for the purpose of keeping out unbidden guests, but for trapping small insects to serve as food for the humming-birds, in return for which the latter effect pollination.

311. Papaya Tourn.

1078. P. carica L. (=Carica Papaya *L.*).—According to Baillon (Bull. soc. linn., Paris, i, 1887), the species is usually dioecious, but often monoecious under cultivation. A plant reared in a greenhouse from Bourbon seed produced flowers which were all male. When transplanted to the open air, the terminal flowers of numerous inflorescences were female, and after these were fertilized the originally male plant set a number of good rapidly growing fruits.

XLVI. ORDER *CUCURBITACEAE* JUSS.

LITERATURE.—Knuth, 'Grundriss d. Blütenbiol.,' p. 55.

Species monoecious, or more frequently dioecious. The male flowers are larger than the female ones, so that insects usually pay their first visits to the former. The nectar is secreted in the bottom of a naked fleshy cup formed by the fusion of the lower parts of calyx and corolla. On the stamens of many species there are numerous glands, which, when their tips are broken off, serve to moisten the pollen-grains and make them sticky, according to Halsted.

Arcangeli (Atti del congresso bot. internaz., 1892, pp. 441–54, Genova, 1893) describes the flower mechanism, and especially the nectaries of various Cucurbitaceae, i. e. Cucurbita maxima *Duch.*, C. Pepo *L.*, Lagenaria vulgaris *Sér.*, Cucumis Melo *L.*, Benincasa, Ecballion, Momordica, and Trichosanthes. Bees are particularly active

as pollinators; in the case of Benincasa cerifera, a humble-bee was also observed. Lagenaria appears to be visited by crepuscular insects (presumably hawk-moths).

The nectaries consist of a layer of secretory tissue about 1 mm. thick, and are provided with water-stomata. The nectar results from the conversion of starch into sugar (glucose) by means of the protoplasm or a special ferment (Solla, Justs bot. Jahresber., Leipzig, xxi (1893), 1896, p. 335).

312. Bryonia L.

Flowers monoecious or dioecious, greenish-yellow in colour; with concealed nectar, secreted as above described. Two pairs of filaments are fused, the fifth is free.

1079. B. dioica Jacq. (Herm. Müller, 'Fertilisation,' pp. 268–70, 'Weit. Beob.,' *II*, p. 210; Ludwig, Verh. bot. Ver., Berlin, xxvi, 1885, p. 21; Schmiedeknecht, 'Apidae europ.,' I, p. 665; Knuth, 'Bloemenbiol. Bijdragen.')—The female flowers of this species are only half as large as the male ones. In the latter, according to Hermann Müller, the filaments spring from the edge of the cup formed by the fusion of the bases of calyx and corolla, and they incline together so as completely to cover the cup. Three narrow lateral passages covered by long hairs lead between the filaments to this nectary, and there is a fourth access from above, running down between the upper ends of the filaments. The anthers dehisce by long narrow clefts, curved in such a way that for most of their length they are turned towards the lateral passages, while their uppermost parts face directly upwards. An insect probing for nectar will therefore be dusted with pollen either on the lower side of its body, or on both sides of its head, and in subsequent visits to female flowers will effect pollination. The female flowers are only half the size of the male ones, and are therefore usually visited later. The style projects from the middle of the nectar-cup, and divides into three diverging branches. The ends of these are very broad, lobed, and set with projecting points, so that an alighting insect is obliged to touch them. Pollen is carried by visitors to a considerable distance. F. Ludwig, for example, observed the crossing of a female plant by pollen from a male plant 40 m. away.

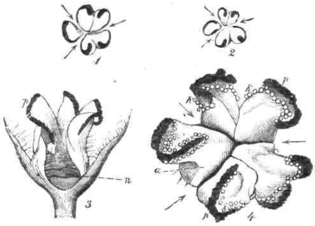


FIG. 154. *Bryonia dioica*, *L.* (after Herm. Müller). (1) and (2) Anthers of male flowers. (3) A male flower in longitudinal section; enlarged. (4) The same, seen from above; further enlarged. *a*, filament; *k*, colourless spherules; *n*, nectary; *p*, pollen. The lateral nectar-passages are indicated by arrows.

VISITORS.—The chief one is the bee Andrena florea *F.* ♀ and ♂, which visits the flowers of this species almost exclusively (Herm. Müller, Schmiedeknecht).—'*It is by far the commonest visitor, and appears to obtain all it requires in the way of flower food from this plant alone*' (Herm. Müller). Schletterer

also records it for Pola as the almost exclusive pollinator of the species, 'constantly enjoying a dip into the flowers.' I have not hitherto succeeded in capturing this rare bee, although white bryony is common in the neighbourhood of Kiel, and I have repeatedly watched the flowers. Of other visitors only those that suck nectar require mention as pollinating agents. For those which devour or collect pollen usually visit none but male flowers, and only occasionally go by mistake to one of the smaller female ones.

Herm. Müller (H. M.), Buddeberg (Budd.), and myself (Kn.) have observed the following.—

A. Coleoptera. *Telephoridae*: 1. Dasytes sp., only on ♂ flowers, po-dvg. (H. M.). **B. Diptera.** (*a*) *Empidae*: 2. Empis livida ♀, skg. (H. M.). (*b*) *Syrphidae*: 3. Ascia podagrica *F.*, po-dvg. (H. M.); 4. Eristalis tenax *L.*, do. (Kn.); 5. Rhingia rostrata *L.*, do. (Kn.); 6. Syrphus balteatus *Deg.*, do. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 7. Andrena florea *F.* ♀ and ♂, skg. and po-cltg. (H. M.); 8. A. fulvicrus *K.* ♂, skg. (H. M.); 9. A. nigroaenea *K.* ♀ and ♂, do. (H. M.); 10. Apis mellifica *L.* ☿, po-cltg. (H. M., Kn.); 11. Coelioxys simplex *Nyl.* ♀, skg. (H. M.); 12. Halictus cylindricus *F.* ♀, do. (Budd.); 13. H. morio *F.* ♂, do. (Budd.); 14. H. sexnotatus *K.* ♀, po-cltg. (H. M.); 15. H. sexstrigatus *Schenck* ♀, do. (H. M.). (*b*) *Sphegidae*: 16. Ammophila sabulosa *L.*, skg. (H. M.); 17. Gorytes mystaceus *L.*, do. (H. M.). (*c*) *Vespidae*: 18. Eumenes pomiformis *F.* ♂, skg. (H. M.); 19. Odynerus parietum *L.* ♀, do. (H. M.).

Schiner saw the Muscid Orellia wiedemanni *Mg.* in Austria; Schletterer the fossorial wasp Pemphredon unicolor *F.* at Pola; and Handlirsch the fossorial wasp Gorytes mystaceus *L.*

1080. B. alba L. (Sprengel, 'Entd. Geh.,' pp. 435–6.)—This species is monoecious. The flower mechanism is the same as that of B. dioica. Hildebrand (Bot. Ztg., Leipzig, li, 1893, p. 30) says that at first purely male inflorescences appear, and ultimately purely female ones. In intermediate stages individual flowers may develop female instead of male organs, and vice versa.

Schmiedeknecht (Thuringia), Friese (Alsace, Hungary, and Switzerland), Saunders and Smith (England), all record Andrena florea *F.* as the exclusive visitor.

Schenck observed the following bees in Nassau.—

1. Andrena cingulata *F.*; 2. A. florea *F.*; 3. A. fucata *Sm.*; 4. A. labialis *K.* ♂; 5. A. labiata *Schenck*; 6. Halictus morio *F.*; 7. H. sexnotatus *K.* ♀.

313. Sicyos L.

Flowers monoecious, greenish-white in colour; with exposed nectar, secreted by a central disk.

1081. S. angulata L. (Knuth, 'Blütenbiol. Herbstbeob.')—This species climbs to a height of several metres, and bears inconspicuous greenish-white blossoms. The male flowers are arranged in corymbs which gradually develop into racemes. There are from ten to twenty flowers in each inflorescence, but as only one (rarely two) matures at a time, the flowering period is prolonged. When the anthers have shed their pollen the flower closes again and soon drops off. The male flower is about 1 cm. in diameter, of which approximately one-third is taken up by a large central secretory disk, while the remaining two-thirds are occupied by the five whitish petals, that are traversed by green veins. From the centre of the disk

the column of filaments rises to a height of 1 mm. It is 2 mm. in diameter, and bears at its apex the united and convoluted anthers, as a rounded mass. Dehiscence takes place in the mature bud.

The female flowers are considerably smaller than the male ones, and are arranged in heads of fifteen to twenty flowers, these too being less conspicuous than the male inflorescences. The latter are therefore (as Sprengel emphasized for Bryonia alba *L.*) usually the first to be noticed and visited by insects, and it is not till they are done with that the less easily observed female flowers receive attention. All the female flowers of an inflorescence mature simultaneously. It is therefore possible or even probable that all may be crossed with the pollen brought at a single insect-visit. The diameter of the female flower is only 4–5 mm. In the middle of the five petals, which resemble those of the male flowers, the style projects to a height of 2 mm. from a small secretory disk. It terminates in three capitate stigmas. These occupy the entrance to the flower, so that a nectar-seeking insect must inevitably touch and pollinate them if it has previously visited a male flower. The large number of visitors to these inconspicuous greenish flowers, as well as their strong action (like those of Bryonia dioica *L.*) on photographic plates, suggested to me that they may possess means of attraction invisible to human eyes though perceptible to those of insects. I expressed the view that the flower pigment of Sicyos (and also of Bryonia) emits ultra-violet rays; but it is also possible that the marked effect upon photographic plates is due to reflection of light by the numerous glands which cover the flowers (*cf.* Vol. I, pp. 87–8; and Nos. 1742, 1743, 1747, in the Bibliography, Vol. I, pp. 285–6).

Visitors.—I observed the following, all freq., skg.—a bee (Apis mellifica *L.*), a wasp (Vespa vulgaris *L.*), and 6 flies (Eristalis nemorum *L.*; Lucilia caesar *L.*, Onesia sepulcralis *L.*; Sarcophaga carnaria *L.*; Sepsis cynipsea *L.*; Syrphus ribesii *L.*).

314. Cucumis L.

Large yellow monoecious flowers, with the same mechanism as Bryonia. Two pairs of filaments are united, the fifth is free. The anthers converge.

1082. C. sativus L. (Sprengel, 'Entd. Geh.,' p. 435.)—In this species again the male flowers are much larger than the female ones, and are therefore usually visited first.

According to the researches of F. Noll, this species, like the fig and Mespilus germanica, var. apyrena *Koch*, can produce ripe but seedless fruits without pollination (parthenocarpy). (Verh. nathist. Ver., Bonn, 1902.)

Visitors.—I only observed the honey-bee, skg., at Kiel ('Bloemenbiol. Bijdragen').

Sickmann records the fossorial wasp Crabro brevis *v. d. L.* for Osnabrück, very common.

1083. C. Melo L. (Aubert, J. soc. horticul. France, Paris, Ser. 3, iii, 1881, p. 233.)—Aubert states that the first female flowers of this species open five to six days after the first male ones, and that the latter are much more numerous. The results of artificial fertilization are seen in two to three days, and the first ripe fruits appear after seven to eight weeks.

315. Cucurbita Juss.

Very large yolk-yellow monoecious flowers; with nectar secreted as in Bryonia.

1084. **C. Pepo** L. (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The male flowers of this species mature somewhat earlier than the female ones, and their stalks are rather longer, so that they are first visited.

Warnstorf states that the calyx and corolla of the male flowers are united at the base, where they support a cup-shaped disk with a tumid edge. Abundant nectar is secreted. This cup is completely covered by the column of stamens, and is only accessible by means of two to four openings at the bases of the filaments. The anthers are extrorse. The pollen-grains are very large, yellow, spherical, prickly; covered with a thin layer of oil, and therefore extremely adhesive; on an average 163 μ in diameter.

Visitors.—I observed the honey-bee, very freq., skg., at Kiel; 2 or even 3 bees were often to be seen in one flower.

316. Sechium P. Br.

1085. **S. edule** Sw.—Arcangeli states that in this species there are two nectaries in the base of both female and male flowers. In the latter they are in the form of small narrow, inconspicuous pockets; in the former they are larger and more conspicuous. The explanation of this is perhaps that insect visitors can only find nectar in the female flowers, while in the male ones they may also obtain pollen.

317. Ecballium A. Rich.

1086. **E. Elaterium** A. Rich.—According to Hildebrand (Bot. Ztg., Leipzig, li, 1893), this species shows the most varied arrangements of the male and female inflorescences. In autumn the last flowers to appear are solitary and female, which can be fertilized by the pollen of earlier male ones.

XLVII. ORDER *CACTEAE* DC.

Hansgirg states that the numerous filaments of many cactus flowers are almost equally sensitive on all sides to mechanical stimulation, curving inwards from the corolla towards the stigmas in response, e.g. in Opuntia Ficus-indica *Mill.*, O. Engelmanni *Salm-Dyck*, O. Camanchica *Engelm. et Bigel.*, and O. Rafinesquii *Engelm.*

318. Opuntia Tourn.

Flowers mostly large, feebly protogynous, and devoid of nectar.

1087. **O. vulgaris** Mill. (=Cactus Opuntia *L.*). (Schulz, 'Beiträge,' II, p. 80.)—The flowers of this species, which is cultivated in South Europe, are nectarless, and Schulz gives their diameter as 30–40 mm. The outermost perianth leaves are greenish-yellow, while the inner ones are of a brilliant sulphur-yellow colour. In dull weather and at night they bend somewhat inwards. The stigmas are receptive at the beginning of anthesis. Before the flowers expand the filaments are curved inwards, but afterwards become more or less erect. The anthers are

at first turned outwards, but subsequently assume an oblique or horizontal position; they are rarely turned inwards. The filaments are somewhat sensitive. They incline inwards on being touched by insects. or even spontaneously, and thickly cover the stigmas with pollen, so that autogamy regularly takes place. It is always effective.

VISITORS.—Schulz records numerous flies, bees, and beetles for Bozen, but especially the beetle Trichodes apiarius *L.*, which devours pollen, stamens, and even petals. He found it in almost every flower, as many as 5–10 in some.

1088. **O. nana** Vis. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 213, 219.)—This species is cultivated in the South Tyrol and in Dalmatia. Kerner describes the flower as having but a short anthesis, opening between 9 and 10 a.m. and losing its petals the following day. It is, however, slightly protogynous, the stigma being receptive a few hours before the anthers dehisce. Towards the end of anthesis, automatic self-pollination is effected, the outer anthers coming into contact with the stigma, which is in the form of a sinuous thickening on the end of the style.

XLVIII. ORDER *UMBELLIFERAE* JUSS.

LITERATURE.—Sprengel, 'Entd. Geh.,' pp. 153–9; Herm. Müller, 'Fertilisation,' pp. 270–1; Drude, in Engler and Prantl, 'D. nat. Pflanzenfam.,' III, 8, pp. 88 et seq.; Knuth, 'Flora d. Prov. Schleswig-Holstein, &c.,' p. 326, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 75–6, 'Grundriss d. Blütenbiol.,' pp. 59–60.

The small flowers are aggregated into inflorescences of considerable size, which are usually compound, often radially symmetrical umbels, less frequently capitula. Insects can therefore see them from a distance. An additional means of attraction is the aromatic odour, often very strong, which characterizes many species. Nectar is secreted by an epigynous disk, and lies freely exposed in the middle of the flower in umbellate species. In capitulate ones (Eryngium and the like) it is concealed in the base of a tube formed by the erect petals. The flowers of most Umbelliferae consequently belong to class **E**, but some to class **S.** As most species are protandrous, cross-pollination by means of insects is possible. The number and diversity of visits are in proportion to the conspicuousness of the inflorescences. Protogyny is rare (Echinophora spinosa *L.*); homogamy occurs here and there.

Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 311) describes the genera Eryngium and Hacquetia as protogynous, because the stamens are at first curved inward like hooks, and the anthers are still closed, when the already sticky shining stigmas project far out of the bud. He also (loc. cit.) describes as protogynous the species of Aethusa, Astrantia, Caucalis, Pachypleurum, Scandix, and Turgenia. I cannot, however, adopt Kerner's view, but agree with the following remarks made by Kirchner on the subject ('Die Blüten der Umbelliferen').—This contention of Kerner's may well be called in question, for it rests on insufficient evidence, and most of it is in contradiction to the observations of other careful observers, as may be seen by consulting the following papers for particular genera.—Aethusa: Sprengel, 'Entd. Geh.,' p. 153; Schulz, 'Beiträge,' II, p. 84. Astrantia: Herm. Müller, 'Fertilisation,' pp. 272–3; Schulz, op. cit., I, p. 41. Caucalis: Schulz, op. cit., I, p. 59. Eryngium: Herm. Müller, op. cit., pp. 271–2; Schulz, op. cit., I, p. 42;

Knuth, Bot. Centralbl., Cassel, xl, 1889, p. 273. Pachypleurum: Herm. Müller, 'Alpenblumen,' p. 120. Sanicula: Herm. Müller, 'Weit. Beob.,' I, p. 303; Schulz, op. cit., I, p. 40. Scandix: Henslow, Trans. Linn. Soc. (Bot.), Ser. 2, i, 1880, p. 365; Schulz, op. cit., I, p. 61. Turgenia: Schulz, op. cit., I, p. 60. As regards Astrantia major *L.*, Eryngium campestre *L.*, and Sanicula europaea *L.*, it is expressly stated by Schulz that the styles project from the hermaphrodite flowers at an early stage, giving the appearance of protogyny, although the stigmas are still immature. Kerner goes too far in his conception of protogyny, when, for example (op. cit., p. 312), he asserts that the Rosaceae and Cruciferae are exclusively protogynous, and (p. 310) even speaks of protogyny when the anthers dehisce ten to fifteen minutes after the flower opens.

Kirchner (op. cit.) discusses protogyny among the Umbelliferae. The first accounts were given by A. F. Foerste (Bot. Gaz., Chicago (Ill.), vii. 1882, pp. 70–1), and W. Trelease (loc. cit.), and have reference to Erigenia bulbosa *Nutt.* The protogyny of this species was subsequently confirmed by C. Robertson (op. cit., xiii. 1888, p. 193), and that of four other North American Umbelliferae was also established, i. e. Sanicula marilandica *L.*, Zizia aurea *Koch*, Pimpinella integerrima *Benth. et Hook. f.*, and Polytaenia Nuttallii *DC.* During the autumn of 1891 Kirchner had the good fortune to observe on the Lido near Venice a case of distinct protogyny in one of the European Umbelliferae, Echinophora spinosa *L.*, the stigmas of which are mature before any of the anthers dehisce.

In protandrous hermaphrodite flowers the stamens ripen successively. When the flower opens, one anther springs up so as to occupy the middle of the flower, its filament being curved. When it has shed its pollen the filament bends back towards the corolla, a second stamen assuming the position of the first, and so on. The styles usually begin to grow when all the stamens of a flower, or even of an umbel, are withered; they then diverge so that the terminal stigmas occupy the middle of the flower.

In correspondence with the exposed position of the nectar in most species, the large majority of guests are short-tongued insects (flies, beetles, wasps, and some bees). Lepidoptera with their long proboscis are only seen occasionally as visitors, but seek out more frequently the flowers of those Umbelliferae which belong to class **S**. The more specialized bees (honey-bees, humble-bees, and the like) also resort in greater numbers to flowers of the latter class, and generally only collect pollen from those of class **E**; sometimes, however, they lick the nectar of such flowers. Many species are andromonoecious.

Warnstorf makes the following remarks (Verh. bot. Ver., Berlin, xxxviii, 1896.)—A definite line of adaptation is noticeable in our native Umbelliferae as regards flower pollination. In order to appreciate this fully, all the inflorescences of a plant or branch have to be considered. It then appears that in by far the greater number of cases, the primary umbel only bears hermaphrodite flowers in its umbellules, there being rarely a few male flowers in the centre, while very rarely all the flowers have become female by the degeneration of the anthers. The last condition is associated with the presence of relatively long styles. In most smaller secondary umbels, as a general rule, the marginal flowers of the umbellules are hermaphrodite only, while the central ones are male: more rarely all are hermaphrodite, as in the

umbellules of the primary umbel. The umbellules of tertiary umbels display a still further diminution of hermaphrodite flowers, and an increase of male ones: either a few marginal hermaphrodite flowers still remain, or these have entirely disappeared, so that the entire umbel is often purely male. If the well-marked protandry of Umbelliferae promotes cross-pollination in a high degree, this is further accentuated by the peculiar distribution of the sexes. Warnstorf found that the anthers of our native species are neither introrse nor extrorse, but dehisce laterally. As, however, the two outer anther-valves curve back towards one another, while the two inner ones retain their original position, the shed pollen faces outwards.

The protandry varies greatly in degree. Beketow ('Ü. d. Proterand. d. Umbellif.,' 1890) found it to be most strongly marked in Anthriscus sylvestris *Hoffm.* and Carum Carvi *L.*, the flowers appearing at first purely male, and afterwards purely female. The first (terminal) umbel, borne by the primary axis, is here very feebly developed; the lateral umbels are much larger, and by elongation of the secondary axis attain a higher level. The terminal umbel is purely female at the time when the lateral ones are still male; the female flowers being at a lower level than the male ones, their geitonogamous pollination is ensured.

Beketow states that protandry is much feebler in Heracleum Sphondylium *L.*, Aegopodium Podagraria *L.*, and Angelica sylvestris *L.*. In these species the primary umbel is larger and at a higher level than the lateral ones. It is possible that this relation between the degree of protandry and the development and position of the various umbels is of more general application. (Rothert, Bot. Centralbl., Cassel, xlv, 1891, p. 381.)

Schulz summarizes his observations somewhat as follows ('Beiträge,' II, pp. 90–1).—

Male flowers are generally associated with hermaphrodite ones; they are either borne on the same or on different stocks. In the former case, they are distributed in one or other of the two following ways.—

1. Hermaphrodite and male flowers are associated either in all the umbels (mixed umbels), or only in some, usually those of a higher order. In the latter case, umbels of a lower order are as a rule entirely hermaphrodite. In mixed umbels both kinds of flower are usually present in all the umbellules; purely male umbellules are not common in most species, and as a rule only occur in the centre of umbels of a higher order. Now and then, however, individual umbels are purely male; in some species, such as Oenanthe fistulosa *L.*, those of the highest order are always so. Most of the species investigated by Schulz belong to this group. The umbellules either bear,—

(*a*) marginal hermaphrodite and central male flowers, except in certain genera where the terminal flower, when present, is usually hermaphrodite; or,

(*b*) the hermaphrodite flowers at the periphery, in the centre (Sanicula europaea *L.*), or an intermediate zone between marginal and central male flowers (Astrantia major *L.*).

2. Hermaphrodite and male flowers are but very seldom associated in the same umbel; only umbels of a higher (or even the highest) order are male. Sometimes, however, all the umbels of a plant are completely hermaphrodite; more rarely flowers

of both kinds are associated in the same umbel, either in the same or in different umbellules. To this group belong, for example, Eryngium campestre *L.* and Laserpitium latifolium *L.*

The two kinds of flower are only found on separate stocks in the case of Trinia glauca *Reichb.* Even in this species, however, plants bearing both kinds sometimes occur—the hermaphrodite flowers being generally in the minority—either in all the umbellules of all or some umbels, or only in some umbellules, as a rule of all the umbels. This variation is either associated with male and hermaphrodite plants, or with male ones only, or it may be quite sporadic. In the case of Trinia, hermaphrodite flowers may also be replaced by female. Female flowers are much rarer than male ones in this order, and it appears that they are not constantly present in any one species. They have been observed in the following cases besides that of Trinia glauca—Eryngium campestre *L.*, Pimpinella magna *L.*, P. Saxifraga *L.*, and Daucus Carota *L.* In Eryngium campestre and the two species of Pimpinella, the female flowers either occur alone or together with neuter ones, but are never associated on the same stock with hermaphrodite or male flowers. The same is the case as a rule for Daucus Carota; but in this species female flowers now and then occur at the periphery of umbellules bearing marginal hermaphrodite flowers and central male ones. Not infrequently the male flowers of the four species mentioned are replaced by neuter ones, though throughout the summer they only possess umbels bearing hermaphrodite flowers, or hermaphrodite and male ones, or ultimately only male ones. Neuter flowers are of sporadic occurrence and in some localities they appear to be wanting altogether. This also applies to the case of Orlaya grandiflora *Hoffm.* The hermaphrodite flowers are protandrous in most species, and in some protandry is so well marked that the styles and stigmas do not attain their full development till after the stamens and petals have fallen off. A number of Umbelliferae, however, bear flowers which are homogamous or but slightly protandrous. These are almost exclusively species that owing to the small number and size of the flowers, and their indistinct white or greenish-white colour, attract but few insect visitors, e.g. Aethusa Cynapium *L.*, Caucaloides daucoides *L.*, Torilis infesta *Roth*, Scandix Pecten-Veneris *L.*, and Anthriscus vulgaris *Bernh.* In the favourite habitats of these species, among corn or dense brushwood, there are but few insects that visit flowers. It is more remarkable that Anethum graveolens *L.* is a homogamous species, for though its flowers are small and produce but little nectar, their brilliant yellow colour makes them very conspicuous, and they possess a powerful aromatic odour. To the foregoing autogamous species I would add Helosciadium inundatum *Koch* (cf. Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 78) and Hydrocotyle vulgaris *L.*

Drude distinguishes the following ways of distribution of the sexes, and order of maturation of stamens and carpels (in Engler and Prantl, 'D. nat. Pflanzenfam.,' III, 8, pp. 89–91).—

A. Flowers monomorphous, all hermaphrodite (except in the feebly developed umbels of higher order).

1. Flowers almost homogamous, the two sexes developing in rapid succession; e.g. Hydrocotyle vulgaris *L.*, Anethum, Aethusa, and others.

2. Flowers strongly protandrous (those of the ultimate lateral umbels being male by reduction). The commonest case.

B. Flowers pleomorphous (☿ and ♂) in the primary umbels.

3. Here belong the common cases of andromonoecism; e. g. Astrantia major *L.*, Chaerophyllum aromaticum *L.*, Scandix Pecten-Veneris *L.*, Torilis Anthriscus *Bernh.*, and so forth.

4. Well-marked monoecism; e. g. Echinophora.

5. Well-marked dioecism; e. g. Arctopus.

C. Flowers of the primary umbels with uniformly reduced male organs; those of the lateral umbels, on the contrary, purely male.

6. Here belong the rare cases of trimonoecism, or of monoecious polygamy; e. g. Ferula.

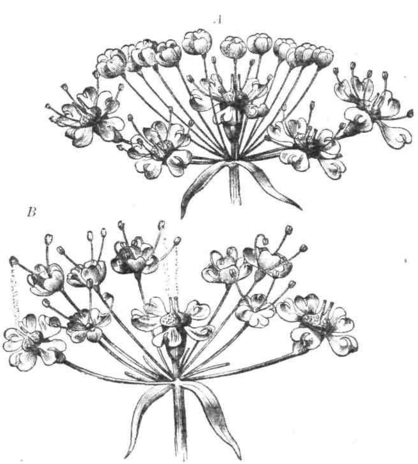


FIG. 155. *Geitonogamy of Chaerophyllum aromaticum, L.* (after Kerner). *A.* The hermaphrodite flowers are open; the pseudo-hermaphrodite pollen flowers are still closed. *B.* The hermaphrodite flowers have lost their stamens; the pseudo-hermaphrodite pollen flowers have opened and are shedding their pollen upon the stigmas of the former.

To division **A** must be added the instance of protogyny discovered by Kirchner in Echinophora spinosa *L.*

Drude (op. cit.) says that if all the different cases are reviewed and compared, it will be recognized that the umbels of this order display a tendency to ensure crossing by preponderating development of female organs in the first flowers to open, and their reduction in those which bloom later. This tendency is seen

even in the third type (C), where hermaphrodite and female flowers are associated, for here the primary umbels possess but few male flowers, while in those which bloom last scarcely any others are present.

Something has already been said about the geitonogamy that so frequently takes place among Umbelliferae (Vol. I, pp. 41–2). Kerner describes some very diverse arrangements of the kind ('Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 323–5). In the crowded capitula of Eryngium and Hacquetia, when the filaments elongate their pollen-covered anthers come into contact with the mature stigmas of neighbouring flowers, in consequence of the divergence of the styles. In Sanicula, Astrantia, and Laserpitium, there is a deviation from this form of geitonogamy owing to the fact that pollen flowers as well as hermaphrodite ones are present; but here again the same thing happens, because the elongating styles bend over and entangle themselves with adjacent flowers, so that their stigmas can take up pollen. The converse is true for Pachypleurum, where the stamens ultimately radiate in an almost stellate manner, and touch the mature stigmas of neighbouring flowers. The relations are similar in the case of Siler; while in Athamanta, Meum, and Chaerophyllum, hermaphrodite and pollen flowers are associated. After the stamens of the former have dehisced and fallen off, the pollen flowers ripen their anthers, and drop their pollen upon the still receptive stigmas of the originally hermaphrodite flowers. (Cf. Fig. 155 *B*.)

For Anthriscus, Foeniculum, Coriandrum, Sium, and Ferulago, Kerner describes inflorescences of two kinds. The umbels that blossom first mostly contain hermaphrodite flowers, with a few scattered pollen flowers, while those which do so later contain only the latter kind. After the stamens of the protandrous hermaphrodite flowers have shed their pollen and fallen off, the stigmas become receptive and remain so for some days. Meanwhile the lateral axes bearing male inflorescences continue growing, so that ultimately their umbels lie above the mature stigmas of the hermaphrodite flowers. These stigmas are consequently pollinated by the shower of pollen from the dehiscing anthers of the pollen flowers.

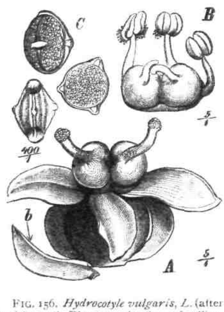


FIG. 156. *Hydrocotyle vulgaris*, *L.* (after Drude). *A.* Flower at the close of pollination: the stamens have fallen off, and the styles are erect (× 5). *B.* Stamens with dehisced anthers; stigmas still immature (× 5). *C.* Dried pollen-grains swollen by immersion in water (× 400), *b*, bract.

319. Hydrocotyle L.

Flowers small, white in colour, and arranged in imperfect umbels; with exposed nectar.

1089. H. vulgaris L. (Herm. Müller, 'Weit. Beob.,' I, pp. 302–3; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 257; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 76; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The flowers of this species are extremely inconspicuous, and only 3–5 of them are found in an umbellule. Hermann Müller says they are so feebly protandrous that automatic

self-pollination can take place, failing insect-visits. The anthers first dehisce in slow succession, but the stigmas mature so early that the last stamen is covered with pollen when they have become receptive. The stigmas come automatically into contact with the pollen so as to bring about autogamy, which is completely effective. I observed it in the North Frisian Islands. Warnstorf says that occasional flowers are often purely female by degeneration of the anthers. The pollen-grains are pale yellow in colour, irregular, either bipyramidal or in the form of a pyramid with convex base, about 25 μ long and 18 μ broad.

1090. **H. americana** L.—

VISITORS.—Henslow records minute Muscids for Kew Gardens.

320. Sanicula L.

Flowers white, andromonoecious, in small sub-globose umbels; with exposed nectar.

1091. **S. europaea** L. (Herm. Müller, 'Weit. Beob.,' I, p. 303; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 257–9; Kirchner, 'Flora v. Stuttgart,' p. 375; Schulz, 'Beiträge,' II, pp. 81–2; Kerner, 'Nat. Hist. Pl.,' Eng. Ed., 1, II, pp. 323–4; Francke, 'Beiträge.')—Hermann Müller states that there are 1–3 protandrous hermaphrodite flowers in each of the small umbels of this species, surrounded by 10–20 purely male ones that mature later. The nectary of the small, bright-reddish flower is a groove bounded by an annular ridge; nectar is secreted in tolerable abundance.

According to Schulz the male flowers may also occur in the middle of the inflorescence, and mature before the hermaphrodite ones.

Other investigators, e. g. Kerner and Francke, describe the flowers as protogynous, so that the mechanism would appear to vary in different districts. Kerner confirms Hermann Müller's statement that there are central hermaphrodite flowers which first mature. The stigmas of these flowers at this stage can only be xenogamously pollinated by insect agency. The filaments subsequently elongate so as to bring the anthers to the same level as the stigmas. As, however, the styles are upright, and the filaments directed obliquely outwards, the anthers and stigmas do not come into contact. Though automatic self-pollination is thus rendered impossible, yet, after the stamens have fallen off, there may be automatic geitonogamy of the originally hermaphrodite flowers, for the styles diverge so as to approach the anthers of adjacent flowers in the same inflorescence.

VISITORS.—Herm. Müller noticed small flies and small beetles (Meligethes). MacLeod saw 2 short-tongued bees and an Empid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 259).

In Dumfriesshire, a Vespid, 2 Muscids, and a Syrphid were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 74).

321. Astrantia L.

Flowers white or reddish in colour, arranged in simple umbels; the concealed nectar is secreted by an epigynous disk. The petals serve as a nectar-cover, being

erect and curved inwards. Andromonoecious or androdioecious; hermaphrodite flowers protandrous.

1092. A. major L. (Herm. Müller, 'Fertilisation,' pp. 272–3; 'Alpenblumen,' p. 116; Knuth, 'Blütenbiol. Herbstbeob.'; Schulz, 'Beiträge,' II, p. 90; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 323–4; Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Hermann Müller states that the white or reddish flowers of this species are not in a continuous plane, as in most Umbelliferae, but conspicuousness of the inflorescences is increased by the broad whitish involucral bracts. Besides protandrous hermaphrodite flowers, each umbel includes numerous marginal and central male ones, and as these usually mature late, they serve to pollinate the last developed stigmas of the hermaphrodite flowers.

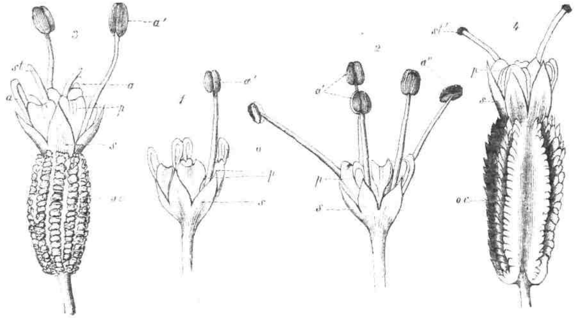


FIG. 157. *Astrantia major*, *L.* (after Herm. Müller). (1) Male flower at the beginning of anthesis; one stamen is erect, but its anther is still unripe; the four other stamens are still bent down within the flower. (2) Male flower, with erect stamens, the anthers of two have dehisced. (3) Hermaphrodite flower at the beginning of anthesis; two stamens are erect, but their anthers have not dehisced; the others are still bent down within the flower. The styles project from the flower, but their stigmas are immature. (4) Hermaphrodite flower in the second (female) stage; the stamens have all fallen off; the styles have elongated and their stigmas are mature. *a*, stamen bent down within the flower; *a'*, erect stamen; *a''*, stamen with dehisced anther; *ov*, ovary; *p*, petal; *s*, sepal; *st*, immature stigma; *st'*, mature stigma.

The male flowers are distributed andromonoeciously or androdioeciously. Schulz says that the male flowers always exceed the hermaphrodite ones in number. Purely female inflorescences are rare. According to Schulz, protandry is so well marked that the stigmas do not become receptive till after the anthers have dehisced. Kerner describes the hermaphrodite flowers as being protogynous, and, like those of Sanicula europaea, geitonogamously fertilized by the pollen of adjacent male ones.

Warnstorf says that primary umbels include both hermaphrodite and male flowers; while secondary ones either contain a few hermaphrodite flowers and numerous male ones, or else the latter only, purely male umbels being the last

to develop. The pollen-grains are white in colour, ellipsoidal, tuberculated, 63 μ long and 25 μ broad.

VISITORS.—Herm. Müller (H. M.) and myself (Kn.) observed the following.—

A. Coleoptera. *Dermestidae*: 1. Anthrenus pimpinellae *F.* (H. M.). **B. Diptera.** (*a*) *Muscidae*: 2. Lucilia caesar *L.* (Kn.); 3. L. cornicina *F.*, nect-lkg. (H. M., Kn.); 4. Miltogramma punctata *Mg.* (H. M.); 5. Onesia sepulcralis, *Mg.*, freq. (Kn.); 6. Pollenia rudis *F.* (Kn.); 7. Sarcophaga carnaria *L.* (Kn.); 8. Scatophaga merdaria *L.* (Kn.); 9. S. stercoraria *L.*, very numerous (Kn.). (*b*) *Syrphidae*: 10. Eristalis arbustorum *L.*, po-dvg. and nect-lkg. (H. M., Kn.); 11. E. nemorum *L.*, common (Kn.); 12. Helophilus floreus *L.* (Kn.); 13. Melanostoma gracilis *Mg.* (Kn.): 14. Syritta pipiens *L.* (Kn.); 15. Syrphus ribesii *L.* (Kn.). **C. Hemiptera.** 16. Lygus (Orthops) kalonii *L.* (Kn.). **D. Hymenoptera.** (*a*) *Apidae*: 17. Andrena albicrus *K.* ♂, skg. (H. M.); 18. Bombus lapidarius *L.* (Kn.); 19. B. terrester. *L.* (Kn.); 20. Prosopis armillata *Nyl.* ♂, skg. (H. M.); 21. P. signata *Pz.* ♂, do.

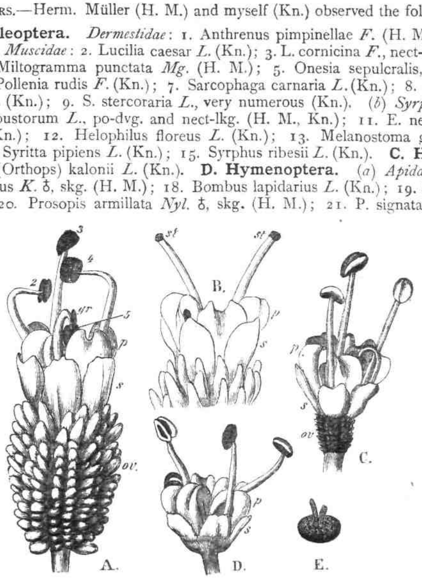


FIG. 158. *Astrantia minor*, *L.* (after Herm. Müller). *A.* Hermaphrodite flower in the first (male) stage. *B.* Upper part of a hermaphrodite flower in the second (female) stage. *C.* Male flower with vestiges of ovary and styles. *D.* Male flower without any such vestiges. *E.* Fleshy disk (with 10 nectar-pits) on the ovary of a male flower. 2, 3, 4, 5, stamens; *gr*, style; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

(H. M.). (*b*) *Sphegidae*: 22. Cerceris arenaria *L.* (Kn.); 23. Oxybelus uniglumis *L.* (Kn.). (*c*) *Vespidae*: 24. Odynerus parietum *L.* (Kn.); 25. Vespa sylvestris *Scop.* (Kn.). **E. Lepidoptera.** *Rhopalocera*: 26. Pieris sp., skg. (Kn.); 27. Vanessa atalanta *L.*, do. (Kn.).

Herm. Müller saw 7 beetles, 3 flies, 2 Hymenoptera, and a Lepidopterid in the Alps. F. F. Kohl noticed 3 true wasps in the Tyrol (Odynerus parietum *L.*; O. trifasciatus *F.*; O. simplex *F.*); and MacLeod 3 Hymenoptera, 3 beetles, and 2 Muscids in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 417–18).

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Graphomyia maculata *Scop.*; 2. Lucilia caesar *L.* (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*; 4. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 5. Apis mellifica *L.*, skg. (*b*) *Sphegidae*: 6. Cerceris variabilis; and on

the var. *intermedia* a Syrphid (Syrphus balteatus *Deg.*): also on the var. *involucrata* Koch.—**A. Coleoptera.** *Coccinellidae*: 1. Coccinella quatuordecimpunctata *L.*, nect-lkg. **B. Diptera.** *Syrphidae*: 2. Eristalis nemorum *L.* **C. Hymenoptera.** (*a*) *Apidae*: 3. Prosopis sp. ♀, po-cltg. (*b*) *Sphegidae*: 4. Oxybelus uniglumis *L.* ☿.

1093. **A. minor** L. (Herm. Müller, 'Alpenblumen,' pp. 114–16.)—The hermaphrodite flowers of this species are protandrous; there are also transitions between andromonoecism and androdioecism. (Cf. Fig. 158.)

VISITORS. Herm. Müller saw a few Muscids.

1094. **A. helleborifolia** Salisb.—

VISITORS.—Loew saw a Muscid (Anthomyia sp.).

1095. **A. neglecta** Koch et Bouché.—

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. E. tenax *L.* **B. Hymenoptera.** (*a*) *Apidae*: 3. Sphecodes gibbus *L.* ♀, skg. (*b*) *Sphegidae*: 4. Crabro spinicollis *H.-Sch.* ♀; 5. Oxybelus sericatus *Gerst.* ♂; 6. Philanthus triangulum *F.* ♀. **C. Lepidoptera.** *Rhopalocera*: Vanessa urticae *L.*, skg.

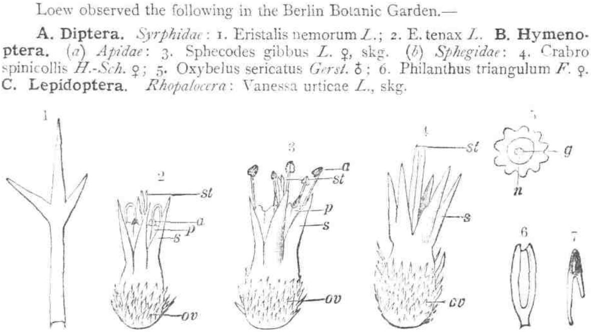


FIG. 159. *Eryngium maritimum, L.* (1–4, enlarged four times from photographs. 5–7, drawn from nature.) (1) Trifurcate bracteole. (2) Late flower-bud; the filaments are still incurved. (3) Flower in the first (male) stage; the anthers have all dehisced; the stigma is not yet mature. (4) Flower towards the end of the second (female) stage; the petals and stamens have fallen off; the stigma is mature. (5) Nectar-secreting disk (× 8). (6) Petal from within (× 5). (7) The same from the side. *a*, stamen; *g*, base of style; *n*, nectary; *ov*, ovary; *p*, petal; *s*, stamen; *st*, stigma.

322. Eryngium L.

Flowers belong to class **S**; arranged in dense capitate umbels; whitish or amethyst-blue in colour; protandrous; with concealed nectar, secreted by an epigynous 10-rayed disk, and protected by the inwardly turned tips of the erect petals. The stiff and extremely sharp involucral bracts and sepals serve as a further protection, as do also the rigid spinous-toothed foliage-leaves. Conspicuousness is brought about not only by the petals, but in some cases by the involucre as well, and even the peduncle may contribute to this end (E. maritimum *L.* and E. amethystinum *L.*).

1096. **E. maritimum** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 76–8, 155; Loew, 'Blütenbiol. Floristik,' p. 390.)—The protandrous flowers of this species are

crowded together into conspicuous dark-blue capitate umbels. These are surrounded by a spinose involucre, which makes it almost impossible for soft-skinned animals like snails or caterpillars to creep up from below, and enter the umbel as unbidden guests. The involucre is supplemented by trifurcate bracteoles, situated at the base of each flower, and also by the five sharply pointed sepals.

The filaments are incurved in the bud, so that the anthers are enclosed in the corolla, which is about 4 mm. long. At this time the bluish colour of the foliage-leaves is not yet well marked, but the whole plant is whitish, and therefore not so conspicuous as later on, when the filaments have elongated and the flowers have entered upon their first (male) stage.

Meanwhile, the 10-rayed disk has begun to secrete. The petals are incurved at the tip, and closely apposed, only leaving a space for the passage of the filaments. This firm approximation of the parts of the flower, and the deep situation of the nectar, makes sucking impossible for any but strong insects with a proboscis at least 3–4 mm. long; and in consequence of this large or middle-sized insects are almost the only visitors observed. These get dusted with pollen from the anthers, which project about 3 mm. beyond the corolla, and when visiting other flowers in the second stage necessarily pollinate the stigmas, which in such flowers are at a corresponding level. In the second stage of anthesis the anthers have dropped off, and the long stigmatic branches project a long way out of the flower. Self-pollination is therefore prevented.

VISITORS.—I observed the following, all skg., on the shores of Kiel Bay, and in Sylt.—

A. Diptera. 1. Syrphus ribesii *L.*; 2. S. umbellatarum *F.* **B. Hymenoptera.** 3. Apis mellifica *L.*; 4. Bombus lapidarius *L.* **C. Lepidoptera.** 5. Lycaena semiargus *Rott.*; 6. Polyommatus phlaeas *L.*; 7. Vanessa atalanta *L.*; 8. V. urticae *L.*

MacLeod observed Apis and other bees, Vespa, and hover-flies, in Belgium.

Loew noticed the following in Mecklenburg ('Beiträge,' p. 41).—

A. Diptera. *Muscidae*: 1. Sarcophaga carnaria *L.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Bombus distinguendus *Mor.* ♀, ☿. and ♂, skg., ☿ and ♀, also po-cltg.; 3. B. soroënsis *F.* ♀, skg. (*b*) *Sphegidae*: 4. Ammophila sabulosa *L.*, skg.; 5. Cerceris arenaria *L.* ♂, do.

1097. E. campestre L. (Herm. Müller, 'Fertilisation,' pp. 271–2; Kerner, 'Nat. Hist. Pl.' Eng. Ed. 1, II, pp. 278, 311, 323; Schulz, 'Beiträge,' I, p. 42; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller describes the flower mechanism of this andromonoecious species as closely resembling that of E. maritimum. The hermaphrodite flowers are protandrous. The nectary here again is a depression surrounded by a ten-lobed ridge, and secreting abundant nectar. This is completely concealed at some depth, for the nectary is surrounded by the five stiff erect petals, which are about 3 mm. long, and sharply incurved at their tips. Outside all are the five rigid awn-like sepals, acuminate in shape and projecting considerably beyond the petals. The sepals, together with the equally stiff and spinose involucral bracts, form an effective protection against unbidden guests. As first pointed out by Schulz, the styles project early from the flower, so that, as in the last species, there is apparent protogyny. It is probably for this reason that Kerner actually describes Eryngium as

protogynous (op. cit., pp. 311, 323). He agrees (op. cit., p. 278), however, with Hermann Müller and others in stating that at the beginning of anthesis only pollen-covered anthers project from all the flowers, and later only styles with receptive stigmas.

FIG. 160. *Eryngium campestre*, *L.* (after Herm. Müller). (1) Flower in the first (male) stage. (2) Flower in the second (female) stage. (3) The same; after removal of sepals, petals, and styles. (4) Petal seen from the inner side. *a'*, mature anther; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, immature stigma; *st'*, mature stigma.

Schulz states that umbels of orders 1 to 3 usually bear only hermaphrodite flowers, while those of the fourth order chiefly contain male ones.

VISITORS.—I observed the following po-dvg. hover-flies; and skg. bees and butterflies in the Botanic Garden of the Kiel Ober-Realschule.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. Syrphus ribesii *L.* **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿; 4. Bombus lapidarius *L.* ♀; 5. B. terrester *L.* ♀ and ☿. **C. Lepidoptera.** *Rhopalocera*: 6. Pieris rapae *L.*; 7. Vanessa atalanta *L.*

Herm. Müller gives the following list.—

A. Diptera. (*a*) *Muscidae*: all skg.: 1. Species of Anthomyia; 2. Echinomyia fera *L.*; 3. Lucilia caesar *L.*; 4. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: all freq.: 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. E. tenax *L.*; 8. Helophilus floreus *L.* **B. Hymenoptera.** All skg. (*a*) *Apidae*: 9. Andrena rosae *Pz.* ♀; 10. Apis mellifica *L.* ☿; 11. Halictus cylindricus *F.* ♂; 12. H. longulus *Sm.* ♂; 13. Nomada robjeotiana *Pz.* ♀. (*b*) *Chrysididae*: 14. Chrysis sp. (*c*) *Sphegidae*: 15. Ammophila sabulosa *L.*, freq.; 16. Cerceris albofasciata *Rossi*, one; 17. C. labiata *F.*, freq.; 18. C. variabilis *Schr.*, not infrequent; 19. Philanthus triangulum *F.*; 20. Salius versicolor *Scop. F.* ♀. (*d*) *Scoliidae*: 21. Tiphia femorata *F.* (*e*) *Vespidae*: 22. Odynerus parietum *L.* ♀; 23. Polistes gallica *L.*, exceedingly common; 24. P. biglumis *L.*, do.

The following are recorded by the observers, and for the localities stated.—

Krieger (Leipzig), the Chrysidid Hedychrum nobile *Scop.* and the fossorial wasp Ammophila affinis *K.* Friese (Hungary), on the authority of Mocsary, the bee Nomia femoralis *Pall.*, freq. F. F. Kohl (Tyrol) the Chrysidid Chrysis rutilans *Oliv.* Rössler (Wiesbaden) the moth Agrotis vestigialis *Rott.* Schiner (Austria), a Syrphid (Merodon analis *Mg.*), and 8 Muscids (1. Anthomyia albescens *Zett.*; 2. Cnephalia bucephala *Mg.*; 3. Melania bifasciata *Mg.*; 4. M. volvulus *F.*; 5. Ocyptera brassicaria *Deg.*; 6. Sarcophaga grisea *Mg.*; 7. Sarcophila latipons *Fall.*; 8. S. meigeni *Schin.*). Plateau (Belgium), the honey-bee and 3 Syrphids (Syritta; Eristalis arbustorum *L.*; E. tenax *L.*).

1098. E. bourgati Gouan.—The flowers of this species are blue in colour, and belong to class **S.**

VISITORS.—MacLeod saw 2 humble-bees, an Eristalis, and 2 Muscids in the Pyrenees.

1099. E. alpinum L.—Christ states that the involucre of this species expands at sunrise, and closes at sunset.

1100. E. amethystinum L.—

VISITORS.—Von Dalla Torre saw the wasp Vespa norwegica *F.* in the Tyrol, where F. F. Kohl noticed 3 wasps (Eumenes pomiformis *F.*; Odynerus dantici *Rossi*; Polistes gallica *L.*).

1101. E. giganteum *Bieb.*—

VISITORS.—Loew saw a humble-bee in the Berlin Botanic Garden (Bombus terrester *L.*, skg.).

1102. E. planum L.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Lucilia caesar *L.* (*b*) *Syrphidae*: 2. Eristalis tenax *L.*; 3. Syritta pipiens *L.*; 4. Syrphus corollae *F.* **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, skg.

323. Conium L.

Flowers white in colour, arranged in compound umbels; with exposed nectar. (All the remaining genera of the order to be considered present these oecological characters, except that the colour of the flowers may be yellow, greenish, or in some cases red.)

1103. C. maculatum L. (Herm. Müller, 'Fertilisation, pp. 274–5,' Weit. Beob.,' I, p. 311; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 79, 156.)—This species will serve to illustrate the protandrous flower mechanism which characterizes most Umbelliferae. Several hundred small white flowers are aggregated into a large compound radiating umbel, which makes the plant very conspicuous; this inflorescence is borne on a stem which may be as much as a metre high. The flowers are distinctly protandrous, and when the bud opens the stamens are at first horizontal in position, and their anthers are unripe. They occupy the intervals between the petals. They then successively become erect, so that the upwardly dehisced anthers lie above the still immature stigmas. When an anther has dehisced, its filament resumes the horizontal position, and another stamen takes its place. All the stamens are completely withered as a rule before the stigmas mature. The styles are then 1 mm. long, so that they are in the same position as that occupied by the anthers during the first (male) stage of anthesis. Numerous

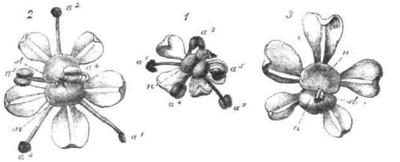


FIG. 161. *Conium maculatum*, *L.* (after Herm. Müller). (1) Flower at the beginning of the first (male) stage. (2) Flower in the middle of the same stage. (3) Flower in the second (female) stage. a^1–a^5, stamens; *n*, nectary; *st*, stigma.

insects (flies, beetles, bees) resort to the nectar secreted by the epigynous disk, and consequently effect cross-pollination.

Kerner says that the flowers exhale a delicate odour of nectar, but the plant as a whole possesses a disagreeable, mouse-like smell.

VISITORS.—I have seen Apis and several other bees, hover-flies (3), Muscidae (4), and the beetle Meligethes, in the North Frisian Islands.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus pimpinellae *F.* (H. M.). (*b*) *Nitidulidae*: 2. Meligethes, freq. (H. M.). (*c*) *Scarabaeidae*: 3. Trichius fasciatus *L.* (H. M.). (*d*) *Telephoridae*: 4. Cantharis fulva *Scop.*, nect-lkg. (H. M.); **B. Diptera.** (*a*) *Dolichopodidae*: 5. Gymnopternus germanus *Wied.*, skg. (H. M.); (*b*) *Muscidae*: 6. Species of Anthomyia (H. M.); 7. Aricia vagans *Fall.* (Budd.); 8. Calliphora vomitoria *L.* (H. M.); 9. Cyrtoneura curvipes *Macq.*, skg. (H. M.); 10. Lucilia cornicina *F.* (H. M.); 11. Musca corvina *F.*, skg. (H. M.); 12. M. domestica *L.* (H. M.); 13. Phasia analis *F.* (Budd.); 14. Scatophaga stercoraria *L.* (H. M.); 15. Sepsis sp. (H. M.). (*c*) *Stratiomyidae*: 16. Chrysomyia formosa *Scop.*, skg. (H. M.); 17. Sargus cuprarius *L.* (H. M.). (*d*) *Syrphidae*: 18. Chrysogaster coemeteriorum *L.*, skg. (H. M.); 19. Eristalis arbustorum *L.* (H. M.); 20. E. nemorum *L.* (H. M.); 21. Helophilus floreus *L.* (Budd.); 22. Syritta pipiens *L.* (Budd.); 23. Syrphus ribesii *L.*, skg. (H. M.). **C. Hemiptera.** 24. Graphosoma lineatum *L.*, skg. (Budd.). **D. Hymenoptera.** (*a*) *Apidae*: 25. Andrena lepida *Schenck* ♂ (H. M.). (*b*) *Ichneumonidae*: 26. Several species. (*c*) *Sphegidae*: 27. Crabro fossorius *L.* ♀, nect-lkg. (Budd.); 28. C. subterraneus *F.* ♂ (Budd.); 29. Gorytes campestris *Müll.* nect-lkg. (Budd.); 30. Pompilus gibbus *F.* ♀ (H. M.). (*d*) *Tenthredinidae*: 31. Hylotoma cyaneocrocea *Forst.*, nect-lkg. (Budd.); 32. H. segmentaria *Pz.*, do. (Budd.); 33. Nematus vittatus *L.* (H. M.); 34. Species of Tenthredo (undetermined) (H. M.). **E. Neuroptera.** 35. Panorpis communis *L.*, nect-lkg. (H. M.).

Alfken and Leege observed the following in Juist.—

A. Coleoptera. (*a*) *Alleculidae*: 1. Cteniopus sulphureus *L.*, one. (*b*) *Coccinellidae*: 2. Coccinella septempunctata *L.*, freq.; 3. C. undecimpunctata *L.* do. **B. Diptera.** (*a*) *Stratiomyidae*: 4. Chrysomyia formosa *Scop.* (*b*) *Syrphidae*: 5. Syrphus balteatus *Deg.*, freq. (*c*) *Muscidae*: 6. Lucilia caesar *L.*, very common. **C. Hymenoptera.** (*a*) *Vespidae*: 7. Odynerus parietum *L.*, several. (*b*) *Sphegidae*: 8. Crabro Crossocerus) wesmaëli *v. d. L.* ♀, do. (*c*) *Scoliidae*: 9. Tiphia femorata *F.*, rare. **D. Neuroptera.** *Planipennia*: 10. Chrysopa abbreviata *Curt.*, skg.

In Dumfriesshire a humble-bee, a wasp, a saw-fly, a Muscid, a hover-fly, and a beetle were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 82).

Friese, on the authority of Korlevič, gives the bee Andrena figurata *Mor.*, rare, for Fiume.

324. Smyrnium L.

1104. S. Olusatrum L.—The flowers of this species are yellowish-green in colour.

VISITORS.—Schletterer, at Pola, noticed the Braconid, Bracon urinator *F.*, and 2 Evaniids (Gasteruption granulithora *Toarn.*; G. rugulosum *Ab.*).

Plateau observed 2 Muscids (Calliphora vomitoria *L.*; Scatophaga sp.) in the Ghent Botanic Garden.

325. **Pleurospermum** Hoffm.

1105. **P. austriacum** Hoffm.—Schulz ('Beiträge,' II, p. 90) has observed this species in the Riesengebirge, bearing only markedly protandrous hermaphrodite flowers. Self-pollination is rare, occurring exceptionally when the stamens happen to be still upright and some pollen remains in their anthers at the time when the stigmas mature.

326. **Cicuta** L.

1106. **C. virosa** L.—Warnstorf states that the umbellules of the primary umbels bear hermaphrodite flowers only; those of the secondary umbels marginal hermaphrodite and central male flowers; and those of tertiary umbels male flowers.

Visitors.—I noticed a Syrphid (Eristalis tenax *L.*) and a Muscid (Lucilia caesar *L.*), both skg. ('Bloemenbiol. Bijdragen').

In Dumfriesshire a humble-bee (freq.), a wasp (freq.), a fossorial wasp, and numerous flies were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 75).

327. **Apium** L.

1107. **A. graveolens** L. Kirchner states that the small whitish flowers of this species are self-fertile, perhaps in consequence of imperfect protandry.

Visitors.—I have observed a Muscid (Scatophaga sp.) and 2 Syrphids (Syritta pipiens *L.*; Syrphus sp.).

328. **Petroselinum** Hoffm.

1108. **P. sativum** Hoffm. Schulz says that the yellowish-green flowers of this species are distinctly protandrous at Bozen. Henslow describes them as homogamous. Schulz also observed andromonoecism. According to Warnstorf, the umbellules of the primary umbels bear hermaphrodite flowers; those of the secondary and tertiary ones, marginal hermaphrodite and central male flowers.

Visitors.—Herm. Müller (H. M.) at Lippstadt, and Buddeberg (Budd.) in Nassau observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Cyrtoneura simplex *Loew* (H. M.); 2. Lucilia cornicina *F.* (H. M.); 3. Sarcophaga carnaria *L.* (H. M.). (*b*) *Syrphidae*: 4. Cheilosia sp. (Budd.); 5. Eristalis arbustorum *L.* (H. M.); 6. E. sepulcralis *L.* (H. M.); 7. Helophilus floreus *L.* (H. M.); 8. Syritta pipiens *L.* (H. M.); 9. Xanthogramma citrofasciata *Deg.* (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 10. Andrena minutula *K.* ♀ (Budd.); 11. A. parvula *K.* ♀ (Budd.); 12. Halictus morio *F.* ♀, nect-lkg. (H. M.); 13. H. nitidus *Schenck* ♀, do. (H. M.); 14. Prosopis communis *Nyl.* (Budd.); 15. P. sinuata *Schenck* ♀, nect-lkg. (H. M., Budd.); 16. Sphecodes gibbus *L.* ♀ and ♂ (H. M., Budd.); 17. Stelis breviuscula *Nyl.* ♂ (Budd.). (*b*) *Chalcididae*: 18. Leucaspis dorsigera *F.*, nect-lkg. (Budd.). (*c*) *Evaniidae*: 19. Foenus sp. (Budd.). (*d*) *Sphegidae*: 20. Crabro clypeatus *Schreb.* ♀, nect-lkg. (Budd.). (*e*) *Vespidae*: 21. Odynerus parietum *L.* ♂ (Budd.); 22. Polistes gallica *L.*, nect-lkg. (Budd.).

Schletterer records the bee Halictus levis *K.* for the Tyrol; and Plateau the honey-bee, a Syrphid (Eristalis tenax *L.*), and 2 Muscids (Musca domestica *L.*; Lucilia caesar *L.*) for Belgium.

329. Trinia Hoffm.

1109. **T. glauca** Reichb. (=T. vulgaris DC.). (Henslow, 'Origin of Floral Structures,' p. 227; Schulz, 'Beiträge,' II, pp. 90, 91, 189.)—Henslow and Schulz describe this species as frequently dioecious, though undoubtedly androdioecious at times. The latter states that female flowers sometimes replace hermaphrodite ones.

330. Helosciadium Koch.

1110. **H. inundatum** Koch (=Apium inundatum *Reichb. f.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 78.)—The flowers of this species are only 2 mm. in diameter. The plants observed by me in the island of Föhr can be effectively self-pollinated, for protandry is ill marked.

1111. **H. nodiflorum** Koch (=Apium nodiflorum *Reichb. f.*).—The flowers of this species are distinctly protandrous. Secretion of nectar stops when the anthers shrivel and begins again when the stigmas mature. It ceases altogether when the petals fall off.

VISITORS.—MacLeod saw 2 Muscids and a Neuropterid in Flanders (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 259–61).

331. Falcaria Riv.

1112. **F. vulgaris** Bernh. (=F. Rivini *Host*, F. sioides *Aschers.*, and Sium Falcaria *L.*). (Schulz, 'Beiträge,' II, p. 190.)—Schulz describes this species as andromonoecious, with markedly protandrous hermaphrodite flowers. The primary umbels usually contain hermaphrodite flowers only; secondary ones now and then bear 1–3 central male flowers, which owing to their position are the first to develop. The rather small tertiary umbels flower late and are purely male.

Warnstorf describes the umbellules of the primary umbels as hermaphrodite; those of the secondary ones as bearing marginal hermaphrodite and central male flowers, or male flowers only. It rarely happens that the umbels bear hermaphrodite flowers.

VISITORS.—Warnstorf observed flies and beetles.

332. Ammi L.

1113. **A. majus** L. Schulz ('Beiträge') describes this species as being andromonoecious, with protandrous hermaphrodite flowers of white colour.

VISITORS.—Schletterer observed an Ichneumonid (Trachynotus foliator *F.*) and a Scoliid (Tiphia minuta *v. d. L.*) at Pola.

333. Aegopodium Knaut.

1114. **A. Podagraria** L. (Herm. Müller, 'Fertilisation,' pp. 266–7, 'Weit. Beob., I, p. 303, 'Alpenblumen,' p. 116; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 78, 155; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 211–54; Loew, 'Blütenbiol. Floristik,' pp. 388, 292.)—Warnstorf says that at Ruppin the umbellules of the primary umbels bear hermaphrodite flowers, those of the secondary umbels

marginal hermaphrodite and central male ones. MacLeod states that in Flanders the flowers of primary umbels are hermaphrodite (or in weaker plants hermaphrodite and male), those belonging to umbels of other orders hermaphrodite on strong plants, and male on weaker ones.

VISITORS.—I observed 4 hover-flies, 3 Muscids, and a Lepidopterid in the island of Föhr.—

Loew observed the following in Brunswick (B.), Silesia (S.), the Harz region (H.) and the Riesengebirge (R.) ('Beiträge,' p. 46).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Callidium violaceum *L.* (S.); 2. Leptura livida *F.* (S.); 3. L. sanguinolenta *F.* (S.); 4. Pachyta octomaculata *F.* (S.); 5. P. virginea *L.* (S.); 6. P. quadrimaculata *L.* (S.); 7. Strangalia arcuata *Pz.* (S.). (*b*) *Oedemeridae*: 8. Chrysanthia viridis *Schmidt* (S.); 9. Oedemera virescens *L.* (S.). (*c*) *Scarabaeidae*: 10. Hoplia philanthus *Sulz.* (B.). (*d*) *Telephoridae*: 11. Dasytes niger *F.*, nect-lkg. (S.); 12. Dictyoptera rubens *Cyll.* (S.); 13. Cantharis melanura *F.* (S.). **B. Diptera.** (*a*) *Asilidae*: 14. Dioctria flavipes *Mg.* (B.). (*b*) *Conopidae*: 15. Conops quadrifasciatus *Deg.* (B.); 16. Sicus ferrugineus *L.* (B.). (*c*) *Muscidae*: 17. Echinomyia grossa *L.* (B.); 18. Graphomyia maculata *Scop.* (B.); 19. Lasiops apicalis *Mg.* (B.); 20. Macquartia chalybeata *Mg.* (B.); 21. M. nitida *Zett.* (B.); 22. Nemoraea erythura *Mg.* (B.); 23. N. pellucida *Mg.* (B.); 24. Siphona cristata *Fabr.* (B.); 25. Zophomyia tremula *Scop.* (B.). (*d*) *Pipunculidae*: 26. Pipunculus rufipes *Mg.* (S.). (*e*) *Stratiomyidae*: 27. Chrysomyia formosa *Scop.* (B.); 28. Odontomyia hydroleon *L.* (B.); 29. Sargus infuscatus *Mg.* (B.). (*f*) *Syrphidae*: 30. Brachyopa ferruginea *Fall.* (S.); 31. Cheilosia variabilis *Mg.* (B.); 32. Chrysochlamys cuprea *Scop.* (B.); 33. Chrysogaster coemeteriorum *L.* (B.); 34. Chrysotoxum festivum *L.* (B.); 35. Pipiza geniculata *Mg.* (B.); 36. Platycheirus albimanus *F.* (S.); 37. Syrphus balteatus *Deg.* (B., S.); 38. S. corollae *F.* (B.); 39. S. glaucius *L.* (B.); 40. S. grossulariae *Mg.* (S.); 41. S. laternarius *Mill.* (B.); 42. S. lineola *Zett.* (B.); 43. S. pyrastri *L.* (B.); 44. S. ribesii *L.* (B.); 45. Volucella inanis *L.* (R.); 46. V. pellucens *L.* (B.). **C. Hemiptera.** 47. Graphosoma lineatum *L.* (B.). **D. Hymenoptera.** (*a*) *Sphegidae*: 48. Cerceris arenaria *L.* ♂ (S.); 49. Crabro cribrarius *L.* ♂ (R.); 50. Gorytes mystaceus *L.* (B.); 51. Mutilla melanocephala *F.* ♂ (S.); 52. Passaloecus corniger *Schuck.* (H.). (*b*) *Tenthredinidae*: 53. Allantus bicinctus *F.* (B.); 54. Dolerus pratensis *L.* (B.); 55. Eriocampa ovata *L.* (B.); 56. Hylotoma ustulata *L.* (B.); 57. Tenthredo flava *Poda* (B.); 58. T. livida *L.* (B.). (*c*) *Vespidae*: 59. Eumenes coarctata *L.*, skg. (B.); 60. Polistes gallica *L.* (R.); 61. Vespa austriaca *Pz.* ♀, skg. (S.); 62. Odynerus gracilis *Brullé* (S.); 63. O. sinuatus *F.*, skg. (B.). **E. Lepidoptera.** *Rhopalocera.* 64. Argynnis paphia *L.* (R.). Also in Mecklenburg ('Beiträge,' p. 35). — **A. Coleoptera.** (*a*) *Telephoridae*: 1. Cantharis fulvicollis *F.*; 2. C. nigricans *Müll.* (*b*) *Oedemeridae*: 3. Oedemera podagrariae *L.* **B. Diptera.** (*a*) *Muscidae*: 4. Graphomyia maculata *Scop.*, skg. (*b*) *Syrphidae*: 5. Tropidia milesiformis *Fall.*, skg. **C. Hymenoptera.** *Sphegidae*: 6. Crabro peltarius *Schreb.* ♀.

Alfken noticed the following at Bremen.—

A. Diptera. *Syrphidae*: 1. Helophilus floreus *L.*, very common. **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena nitida *Fourcr.* ♀, rare; 3. A. parvula *K.* ♀, rare; 4. A. proxima *K.* ♀, not infrequent; 5. Prosopis communis *Nyl.* ♀ and ♂, freq.; 6. P. confusa *Nyl.* ♂, nect-dvg. (*b*) *Tenthredinidae*: 7. Hemichroa alni *L.* **C. Coleoptera.** *Scarabaeidae*: 8. Cetonia aurata *L.*, freq.; 9. Guorinnus nobilis *L.*, rare.

I saw 3 Muscids (Coelopa frigida *Fall.*, skg. and po-dvg.; Fucellia fucorum

Fall., do.; Lucilia caesar *L.*, do.) in Helgoland (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 34).

Sickmann observed the following at Osnabrück.—

Hymenoptera. (*a*) *Mutillidae*: 1. Methoca ichneumonides *Ltr.* a ♂; 2. Mutilla melanocephala *F.* ♂. (*b*) *Scoliidae*: 3. Tiphia minuta *v. d. L.*, not freq. (*c*) *Sphegidae*: 4. Agenia hyrcana *F.*, not freq.; 5. Ammophila hirsuta *Scop.*, not rare; 6. Ceropales maculatus *F.*, freq.; 7. Crabro albilabris *F.*, very common; 8. C. brevis *v. d. L.*, do.; 9. C. chrysostoma *Lep.*, freq.; 10. C. clavipes *L. Dahlb.*, not freq.; 11. C. fuscitasis *H. Sch.*, rare; 12. C. lituratus *Pz.*, do.; 13. C. peltarius *Schreb.*, very common; 14. C. planifrons *Thoms.*, very rare; 15. C. podagricus *v. d. L.*, freq.; 16. C. scutellatus *Schev.*, fairly freq.; 17. C. sexcinctus *F.*, freq.; 18. C. spinicollis *H. Sch.*, freq.; 19. C. vagabundus *Pz.*, do.; 20. C. vagus *L.*, do.; 21. C. wesmaëli *v. d. L.*, not freq.; 22. Dinetus gultatus *F.*, very common; 23. Dolichurus corniculus *Spin.*, rare; 24. Gorytes campestris *Müll.*, do.; 25. G. mystaceus *L.*, freq.; 26. G. quadrifasciatus *F.*, do.; 27. Miscophus bicolor *Jur.*, not infrequent; 28. Nysson maculatus *F.*, fairly freq.; 29. N. spinosus *Forst.*, do.; 30. Oxybelus uniglumis *L.*, freq.; 31. Passaloecus brevicornis *A. Mor.*, rare; 32. Pompilus nigerrimus *Scop.*, freq.; 33. P. spissus *Schjödte*, freq.; 34. P. gibbus *F.*, very common; 35. Psen atratus *Pz.*, freq.; 36. P. concolor *Dahlb.*, infrequent.; 37. Pseudagenia carbonaria *Scop.*, very common; 38. Salius hyalinatus *F.*, freq.; 39. S. notatus *Rossi*, do.; 40. S. sepicola *Sm.*, do.; 41. Trypoxylon attenuatum *Sm.*, rare; 42. T. clavicerum *Lep.*; 43. T. figulus *L.*, very common.

The following were recorded by the observers, and for the localities stated.—

Schmiedeknecht (Thuringia) the bee Andrena combinata *Chr.* Krieger (Leipzig), 4 bees (Colletes daviesanus *K.*; Prosopis communis *Nyl.*; P. hyalinata *Sm.*; P. pictipes *Nyl.*). MacLeod (Flanders) Apis, 5 short-tongued bees, 28 other short-tongued Hymenoptera, 12 hover-flies, 16 other flies, 12 beetles, a Lepidopterid, and a Neuropterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 262–4). H. de Vries (Netherlands) the bee Andrena trimmerana *K.* ♀ (Ned. Kruidk. Arch., Nijmegen, 2 Ser., 2 Deel, 1875). Scott-Elliot (Dumfriesshire) a fossorial wasp, a Vespid, 2 Ichneumonids and 2 Muscids ('Flora of Dumfriesshire,' p. 76).

Herm. Müller (H. M.), Buddeberg (Budd.), and Borgstette (Borg.) give the following list.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Grammoptera ruficornis *F.* (H. M.); 2. Leptura livida *F.* (H. M.); 3. Pachyta octomaculata *F.* (Borg.). (*b*) *Cistelidae*: 4. Cistela murina *L.* (H. M.). (*c*) *Curculionidae*: 5. Spermophagus cardui *Stev.* (H. M.). (*d*) *Cleridae*: 6. Trichodes apiarius *L.* (H. M.). (*e*) *Dermestidae*: 7. Anthrenus pimpinellae *F.* (H. M.). (*f*) *Elateridae*: 8. Agriotes aterrimus *L.* (H. M.); 9. Athous niger *L.* (H. M.); 10. Lacon murinus *L.* (H. M.). (*g*) *Mordellidae*: 11. Anaspis rufilabris *Gyll.* (H. M.); 12. A. frontalis *L.* (H. M.); 13. Mordella aculeata *L.*, very common (H. M.); 14. M. fasciata *F.* (H. M.). (*h*) *Nitidulidae*: 15. Cychramus luteus *Oliv.* (H. M., Borg.). (*i*) *Oedemeridae*: 16. Oedemera virescens *L.* (H. M.). (*k*) *Scarabaeidae*: 17. Cetonia aurata *L.* (H. M.); 18. Hoplia argentea *Poda* (H. M., in the Alps); 19. Phyllopertha horticola *L.* (H. M.); 20. Trichius fasciatus *L.* (H. M.). (*l*) *Telephoridae*: 21. Dasytes flavipes *F.* (H. M.); 22. Malachius bipustulatus *L.* (H. M.); 23. Telephorus fuscus *L.* (H. M.). (*m*) *Trixagidae*: 24. Trixagus fumatus *F.* (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 25. Anthrax flava *Mg.* (H. M.). (*b*) *Dolichopodidae*: 26. Gymnopternus chaerophylli *Mg.* (H. M.). (*c*) *Empidae*: 27. Empis livida *L.* (H. M.); 28. E. punctata *F.* (H. M.). (*d*) *Muscidae*: 29. Species of Anthomyia (H. M.); 30. Aricia obscurata *Mg.* (H. M.); 31. Echinomyia fera *L.* (H. M.); 32. Lucilia cornicina *F.* (H. M.); 33. L. sylvarum *Mg.* (H. M.); 34. Musca corvina *F.* (H. M.); 35. Sarcophaga albiceps *Mg.* (H. M.); 36. Scatophaga

stercoraria *L.*(H.M.); 37. S. merdaria *F.*(H.M.); 38. Sepsis, freq. (H.M.); 39. Zophomyia tremula *Scop.* (H. M.). (*e*) *Stratiomyidae*: 40. Chrysomyia formosa *Scop.* (H.M.); 41. Sargus cuprarius *L.* (H. M.); 42. Stratiomys chamaeleon *Deg.* (H. M.). (*f*) *Syrphidae*: 43. Chrysogaster chalybeata *Mg.* (H. M.); 44. C. coemeteriorum *L.* (H. M.); 45. C. viduata *L.* (H. M.); 46. Eristalis arbustorum *L.* (H. M.); 47. E. nemorum *L.* (H. M.); 48. E. tenax *L.* (H. M.); 49. Helophilus floreus *L.*, freq. (H. M.); 50. Melithreptus taeniatus *Mg.* (H. M.); 51. Pipizella virens *F.* (H. M.); 52. Syritta pipiens *L.*, freq. (H. M.); 53. Syrphus nitidicollis *Mg.* (H. M.); 54. S. pyrastri *L.* (H. M.); 55. S. ribesii *L.* (H. M.); 56. Volucella pellucens *L.* (Borg.). (*g*) *Therevidae*: 57. Thereva anilis *L.* (H. M.). (*h*) *Tipulidae*: 58. Pachyrhina crocata *L.* (H. M.); 59. P. histrio *F.* (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 60. Andrena albicans *Müll.*, skg. (H. M.); 61. A. albicrus *K.* ♀ (H. M.); 62. A. dorsata *K.* ♀, po-cltg. (H. M.); 63. A. fucata *Sm.* ♀, skg. (H. M.); 64. A. fulvago *Chr.* ♀, po-cltg. (H. M.); 65. A. helvola *L.* ♀ and ♂, po-cltg. and skg. (H. M.); 66. A. parvula *K.* ♀ and ♂ (H. M.); 67. A. pilipes *F.* ♂, skg. (H. M.); 68. A. proxima *K.* ♀, skg. and po-cltg. (H. M.); 69. Apis mellifica *L.* ☿, do. (H. M.); 70. Halictus albipes *F.* ♀, skg. (H. M.); 71. H. cylindricus *F.* ♀, do. (H. M.); 72. H. minutus *K.* ♀, do. (H. M.); 73. Prosopis clypearis *Schenck* ♂, do. (H. M.); 74. P. communis *Nyl.* ♂, do. (H.M.). (*b*) *Chrysididae*: 75. Hedychrum lucidulum *F.* ♂, in great numbers (H. M.). (*c*) *Evaniidae*: 76. Foenus affectator *F.* (H. M.); 77. F. jaculator *F.* (H. M.). (*d*) *Ichneumonidae*: 78. Numerous sp. (H. M.). (*e*) *Sphegidae*: 79. Cerceris variabilis *Schr.* ♀ and ♂, rare (H. M.); 80. Crabro interruptefasciatus *Retz.* ♂ (H. M.); 81. C. lapidarius *Pz.* ♀ (H. M.); 82. C. sexcinctus *F.* ♂ (H. M.); 83. C. vagus *L.* ♀ (H. M.); 84. Gorytes campestris *Müll.* ♀ and ♂, not infrequent (H. M.); 85. G. laticinctus *Schuck.* ♀ (H. M.); 86. Myrmosa melanocephala *F.* ♀ (H. M.); 87. Oxybelus lineatus *F.* ♂, numerous; 88. O. bellus *Dahlb.* ♂ (H. M.); 89. O. bipunctatus *Ol.* ♂; 90. O. uniglumis *L.*, very numerous (H. M.); 91. Philanthus triangulum *F.* (H. M.). (*e*) *Pompilidae*: 92. Pompilus minutus *Dahlb.* ♀ (H. M.); 93. P. nigerrimus *Scop.* ♀ (Borg.); 94. P. spissus *Schjödte* ♀ (H. M.). (*f*) *Tenthredinidae*: all nect-lkg.: 95. Abia sericea *L.* (H. M.); 96. Allantus arcuatus *Forst.*, freq. (H.M.); 97. Hylotoma caeruleopennis *Retz.* (H. M.); 98. H. melanochroa *Gmel.* (H. M.); 99. H. rosae *L.* (H. M.); 100. H. ustulata *L.* (H. M.); 101. Selandria serva *F.*, freq. (H. M.); 102. Tenthredo atra *L.* (Budd.); 103. T. bifasciata *Klg.* (=Allantus rossii *Pz.*) (H. M.); 104. T. flavicornis *F.* (H. M.); 105. T. sp. (H. M.). (*g*) *Vespidae*: 106. Odynerus elegans *Wsm.* ♀, nect-lkg. (H. M.); 107. O. quinquefasciatus *F.* ♀, do. **D. Lepidoptera.** *Rhopalocera*: 108. Pieris napi *L.*, skg. (H. M.). **E. Neuroptera.** 109. Panorpa communis *L.* (H. M.).

1115. **A. alpestre** Ledb.—

VISITORS.—Loew observed a Muscid (Chloria demandata *F.*) and a bee (Andrena fasciata, *Wesm.* ♀), skg. and po-cltg., in the Berlin Botanic Garden.

334. **Carum** Rupp.

1116. **C. Carvi** L.—Beketow (Justs bot. Jahresber., Cassel, xviii (1890), 1892, p. 464) points out that protandry in this species is so marked that the primary umbel is purely female at the time when the flowers of the lateral ones are in the male stage.

Warnstorf (Schr. natw. Ver., Weringerode, xi, 1896) states that the primary umbel bears either hermaphrodite flowers, or ones that have become purely female by the degeneration of the pollen-grains in the white anthers, borne on relatively short filaments. Should the primary umbel be purely female, the others are usually hermaphrodite; though an entire stock may often be female, as a result of degeneration of the anthers. At Ruppin, therefore, the species is gynodioecious.

The pollen-grains are white, biscuit-shaped, somewhat contracted in the middle, with 3 longitudinal furrows, about 30 μ long and 12 μ broad.

VISITORS.—I observed (Helgoland, 5. 6. '97) a Muscid (Lucilia caesar *L.*), Syrphids (sp. of Eristalis and Syrphus), and beetles (Cantharis).

Lindman noticed ripe fruits on the Dovrefjeld, and records several species of flies and a bee, as visitors.

Herm. Müller observed the following ('Fertilisation,' pp. 275–6; 'Weit. Beob.,' I. p. 304).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia atra *Laich.*, nect-lkg. (*b*) *Chrysomelidae*: 2. Crioceris duodecimpunctata *L.* (*c*) *Curculionidae*: 3. Bruchus sp., numerous; 4. Phyllobius oblongus *L.* (*d*) *Telephoridae*: 5. Anthocomus fasciatus *L.*; 6. Dasytes flavipes *F.*, nect-lkg.; 7. Malachius bipustulatus *L.*; 8. Telephorus fuscus *L.*, nect-lkg.; 9. T. lividus *L.*, do.; 10. T. pellucidus *F.*, do.; 11. T. rusticus *Fall.* (*e*) *Mordellidae*, all nect-lkg.: 12. Anaspis rufilabris *Gyll.*; 13. Mordella pumila *Gyll.*; 14. M. pusilla *Dej.* (*f*) *Staphylinidae*: 15. Tachinus fimetarius *Grv.*, nect-lkg.; 16. Tachyporus solutus *Er.*, do. **B. Diptera.** (*a*) *Bibionidae*: 17. Bibio hortulanus *L.* (*b*) *Empidae*: 18. Empis stercorea *L.*, skg. (*c*) *Muscidae*: 19. Aricia incana *Wiedem.*; 20. Cyrtoneura hortorum *Fall.* ♀; 21. Echinomyia fera *L.*; 22. Gymnosoma rotundata *L.*; 23. Species of Lucilia; 24. Pyrellia aenea *Zett.*; 25. Sarcophaga carnaria *L.*; 26. S. albiceps *Mg.*; 27. Scatophaga merdaria *F.*; 28. Zophomyia tremula *Scop.* (*d*) *Stratiomyidae*: 29. Chrysomyia formosa *Scop.*; 30. Stratiomys longicornis *Scop.* (*e*) *Syrphidae*: 31. Chrysotoxum festivum *L.*; 32. Eristalis aeneus *Scop.*; 33. E. arbustorum *L.*; 34. E. horticola *Deg.*; 35. Helophilus floreus *L.*, very common; 36. H. pendulus *L.*; 37. Melanostoma mellina *L.*; 38. Melithreptus taeniatus *Mg.*; 39. Pipizella virens *F.*; 40. Platycheirus peltatus *Mg.*; 41. Pyrophaena sp., skg.; 42. Syritta pipiens *L.*; 43. Syrphus ribesii *L.*, skg. (*f*) *Tipulidae*: 44. Tipula sp., nect-lkg. **C. Hemiptera.** 45. One small Capsus. **D. Hymenoptera.** (*a*) *Apidae*: all skg.: 46. Andrena albicans *Müll.* ♀ and ♂, skg.; 47. A. fulvicrus *K.* ♀; 48. A. minutula *K.* ♀; 49. A. nana *K.* ♂; 50. A. nigroaenea *K.* ♀; 51. A. parvula *K.*, skg. and po-cltg.; 52. Halictus albipes *F.* ♀, po-cltg.; 53. H. maculatus *Sm.* ♀, skg., repeatedly; 54. H. sexnotatus *K.* ♀, po-cltg.; 55. Prosopis brevicornis *Nyl.* ♂; 56. P. communis *Nyl.* ♂. (*b*) *Formicidae*: 57. Formica fusca *L.* ☿; 58. Lasius niger *L.* ☿; 59. Myrmica rugulosa *Nyl.* ☿; 60. M. levinodis *Nyl.* ☿. (*c*) *Ichneumonidae*: 61. Numerous species. (*d*) *Pteromalidae*: 62. An undetermined sp., nect-lkg. (*e*) *Sphegidae*: 63. Pemphredon unicolor *F.*, several; 64. Crabro lapidarius *Pz.* ♀; 65. C. scutellatus *Schev.* ♂; 66. C. vagabundus *Pz.* ♀; 67. Gorytes campestris *Müll.* ♂. (*f*) *Tenthredinidae*: 68. Athalia spinarum *F.*; 69. Cephus niger *Harr.*; 70. Abia sericea *L.*; 71. Dolerus pratensis *L.*; 72. Hylotoma caerulescens *F.*; 73. H. enodis *L.*; 74. H. femoralis *Klg.*; 75. H. rosarum *Klg.*; 76. Selandria serva *F.*; 77. Tenthredo bifasciata *Klg.*; 78. Allantus vespa *Retz.* **E. Lepidoptera.** (*a*) *Tineidae*: 79. Adela sp., skg. **F. Neuroptera.** *Planipennia*: 80. Sialis lutaria *L.*

Verhoeff observed the following in Norderney.—

A. Diptera. (*a*) *Empidae*: 1. Hilara quadrivittata *Mg.* (*b*) *Dolichopodidae*: 2. Dolichopus aeneus *Deg.* (*c*) *Muscidae*: 3. Anthomyia sp. ♂ (2); 4. A. sp., freq.; 5. A. triquetra *Wiedem.* one ♂; 6. Aricia incana *Wiedem.*; 7. A. obscurata *Mg.* one ♂; 8. Cyrtoneura hortorum *Fall.* one ♀ and one ♂; 9. Hylemyia conica *Wiedem.* one ♂; 10. Limnophora quadrimaculata *Fall.* ♀ and ♂; 11. Lucilia caesar *L.*, freq.; 12. Myospila meditabunda *F.*; 13. Onesia floralis *R.-D.*; 14. Psila villosula *Mg.*; 15. Sarcophaga sp. ♀; 16. Scatophaga stercoraria *L.* one ♀. (*d*) *Syrphidae*: 17. Pipizella virens *F.*

one ♂; 18. Syritta pipiens *L.* one ♀. (*e*) *Therevidae*: 19. Thereva anilis *L.* one ♂. (*f*) *Tipulidae*: 20. Pachyrhina scurra *Mg.* one ♀. **B. Hymenoptera.** *Tenthredinidae*: 21. Nematus sp.

The following were recorded by the observers, and for the localities stated.—

Alfken (Bremen) 6 Tenthredinids.—1. Allantus temulus *Scop.*; 2. Arge enodis *L.*; 3. A. ustulata *L.*; 4. Dolerus fissus *Htg.*; 5. Macrophya quadrimaculata *F.*; 6. Pachyprotasis rapae *L.* Herm. Müller (Alps) 7 Diptera, 4 Hymenoptera, and 6 Lepidoptera ('Alpenblumen,' p. 116). Schletterer and von Dalla Torre (Tyrol) the bee Prosopis borealis *Nyl.* Kohl the fossorial wasp Crabro scutellatus *Schev.* MacLeod (Pyrenees) a bee and 2 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 413–14). Scott-Elliot (Dumfriesshire) a saw-fly, 2 Ichneumonids, 5 Muscids, and several Dolichopodids ('Flora of Dumfriesshire,' p. 76).

335. Pimpinella L.

1117. **P. magna** L. (Schulz, 'Beiträge,' I, p. 43, II, pp. 82–4, 91, 190.)—Schulz, for Germany and the Tyrol, describes this species as andromonoecious, with protandrous hermaphrodite flowers. Gelmi and Schulz, in the South Tyrol, observed a purely female form with partly or completely degenerate pollen: the central flowers

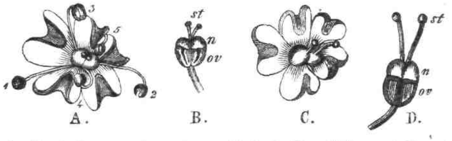


FIG. 162. *Pimpinella magna, L., var. β rosea, Koch* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Pistil of the same. *C.* Flower in the second (female) stage. *D.* Pistil of the same. (× 7.) 1–5, stamens; *n*, nectary; *ov*, ovary; *st*, stigma.

of the umbels were neuter, instead of being male as usual. Gelmi states that the styles are always shorter than the ovary in the hermaphrodite flowers, but longer in the purely female ones. The same is true for P. saxifraga. At Ruppin, according to Warnstorf, the umbellules of primary umbels bear hermaphrodite flowers; those of secondary umbels marginal hermaphrodite and central male ones; tertiary umbels male flowers only.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Central Germany), 2 bees (Andrena parvula *K.* ♀, skg. and po-cltg.; A. rosae *Pz.* ♀, skg.) ('Fertilisation,' p. 277); in the Alps a Cerambycid beetle (Pachyta quadrimaculata *L.*) ('Alpenblumen,' p. 116). Sickmann (Osnabrück), 2 fossorial wasps (Crabro dives *Lep.*, rare; Mellinus sabulosus *F.*). MacLeod (Pyrenees), a beetle (Bot Jaarb. Dodonaea, Ghent, iii, 1891, p. 413).

In the sub-Alpine region this species usually bears rose-red flowers (var. β *rosea* Koch, = the species Pimpinella rubra *Hoppe*), and the styles and stigmas appear to be developed to such an extent in the first (male) stage, that they might be regarded as mature, but as a matter of fact they do not attain their full size till later.

VISITORS.—The following were recorded by the observers and for the localities stated.—

Herm. Müller, 7 flies, 2 Hymenoptera, and a Lepidopterid. von Dalla Torre and Schletterer (Tyrol), 3 bees (Halictus major *Nyl.*; H. tetrazonius *Klug.*; H. zonulus *Sm.*). MacLeod (Pyrenees), a saw-fly, a beetle, and 6 flies (loc. cit.).

1118. **P. saxifraga** L. (Loew, 'Blütenbiol. Floristik,' pp. 379, 389, 393; Herm. Müller, 'Fertilisation,' pp. 277–8, 'Weit. Beob.,' I, p. 304; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 155; Schulz, 'Beiträge,' I, p. 44, II, pp. 84, 91, 190.)—Both Gelmi and Schulz state that this species resembles the chief form of P. magnum as regards flower mechanism. It is mostly andromonoecious, but now and then gynodioecious. (Cf. the last species.)

At Ruppin, according to Warnstorf, the umbellules of primary umbels bear hermaphrodite flowers; those of the secondary umbels marginal hermaphrodite and central male ones.

VISITORS.—Herm. Müller in Westphalia and Buddeberg (Budd.) in Nassau observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *F.*, nect-lkg.; 2. Pachyta octomaculata *F.*, freq., licking sap. (*b*) *Coccinellidae*: 3. Coccinella septempunctata *L.*, creeping over the flowers. (*c*) *Chrysomelidae*: 4. Clytra scopolina *L.* (*d*) *Telephoridae*: 5. Dasytes flavipes *F.*; 6. Telephorus melanurus *K.* **B. Diptera.** (*a*) *Asilidae*: 7. Isopogon brevirostris *Mg.* (*b*) *Conopidae*: 8. Conops quadrifasciata *Deg.* (*c*) *Syrphidae*: 9. Eristalis horticola *Mg.*; 10. Syrphus nitidicollis *Mg.*; 11. S. pyrastri *L.* (*d*) *Tabanidae*: 12. Chrysops caecutiens *L.*; 13. Tabanus nicans *Mg.* **C. Hymenoptera.** (*a*) *Apidae*: 14. Andrena fulvescens *Sm.* ♀; 15. A. parvula *K.*, skg. and po-cltg.; 16. Sphecodes gibbus *L.*, skg. (*b*) *Ichneumonidae*: numerous sps. (*c*) *Tenthredinidae*: 17. Abia sericea *L.*; 18. Allantus arcuatus *Forst.*, freq. (H. M., Budd.); 19. A. temulus *Scop.*; 20. Hylotoma rosae *L.*; 21. Selandria serva *F.* **D. Neuroptera.** *Plannipennia*: 22. Panorpa communis *L.*

The following were recorded by the observers, and for the localities stated.—

Lindman (Dovrefjeld), a saw-fly. Schletterer (Tyrol), the Scoliid Tiphia femorata *F.* Alfken (Bremen):—**A. Diptera.** *Syrphidae*: 1. Chrysotoxum festivum *L.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Prosopis communis *Nyl.* ♀ and ♂. (*b*) *Sphegidae*: 3. Ceropales maculatus *F.*, very common; 4. Crabro brevis *v. d. L.* ♀ and ♂. (*c*) *Tenthredinidae*: 5. Allantus arcuatus *Forst.*; 6. Athalia glabricollis *Jhs.* (Juist), **A. Coleoptera.** *Alleculidae*: 1. Cteniopus sulphureus *L.*, freq., po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Lucilia caesar *L.*; 3. Nemoraea radicum *F.*, very common, po-dvg.; 4. Sarcophaga albiceps *Mg.* (*b*) *Syrphidae*: 5. Eristalis tenax *L.* Sickmann (Osnabrück): **Hymenoptera.** *Sphegidae*: 1. Crabro lituratus *Pz.*; 2. Gorytes tumidus *Pz.*, infrequent: 3. Mellinus sabulosus *F.*, rare. MacLeod (Flanders) 12 short-tongued Hymenoptera, 10 hover-flies, 14 other flies, and Panorpa (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 265–6); (Pyrenees) 8 short-tongued Hymenoptera, 4 beetles, and 10 flies (op. cit., iii, 1891, pp. 412, 414). Scott-Elliot (Dumfriesshire), a saw-fly and numerous flies ('Flora of Dumfriesshire,' p. 47).

I observed the following in Thuringia ('Blütenbiol. Beob. in Thüringen,' p. 32).—

A. Coleoptera. 1. Judolia cerambyciformis *Schr.*, freq.; 2. Leptura livida *F.*; 3. Strangalia melanura *L.*; 4. Trichius fasciatus *L.* **B. Diptera.** (*a*) *Muscidae*: 5. Aricia serva *Mg.* (*b*) *Syrphidae*: 6. Syrphus lineola *Zett.*; 7. Volucella pellucens *L.* **C. Lepidoptera.** 8. Zygaena pilosellae *Esp.*

Loew (Riesengebirge) ('Beiträge,' p. 48).—

A. Coleoptera. *Cerambycidae*: 1. Strangalia nigra *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Meigenia floralis *Mg.* (*b*) *Syrphidae*: 3. Cheilosia oestracea *L.*; 4. Eristalis rupium *F.* **C. Hymenoptera.** *Ichneumonidae*: 5. Undetermined sp. (Mecklenburg) (op. cit., p. 37):—**Hymenoptera.** (*a*) *Apidae*: 1. Prosopis annularis *Sm.* ♀; 2. P. sp. (*b*) *Chrysididae*: 3. Chrysis saussurei *Chevr.* (*c*) *Vespidae*: 4. Odynerus spinipes *L.*; 5. Pterocheilus phaleratus *Pz.*

Willis records the following for the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. (*a*) *Telephoridae*: 1. Rhagonycha fulva *Scop.*, skg. (*b*) *Nitidulidae*: 2. Epuraea melina *Er.*, skg.; 3. Meligethes sp., do. **B. Diptera.** (*a*) *Empidae*: 4. Ramphomyia tenuirostris *Fall.*, skg. (*b*) *Muscidae*: all skg.: 5. Anthomyia radicum *L.*, freq.; 6. A. sp.; 7. Hyetodesia incana *W.*; 8. Lucilia caesar *L.*; 9. Morellia curvipes *Mcq.*; 10. Phorbia floccosa *Mcq.*; 11. Anthomyia radicum *L.*; 12. Themira minor *Hal.*, freq.; 13. Lasiops cunctans *Mg.* (*c*) *Phoridae*: 14. Phora sp., skg. (*d*) *Syrphidae*: all skg.: 15. Cheilosia sp.; 16. Chrysogaster splendida *Mg.*; 17. Eristalis aeneus *Scop.*, freq.; 18. E. horticola *Deg.*, do.; 19. E. tenax *L.*; 20. Orthoneura nobilis *Fall.*; 21. Sphaerophoria scripta *L.*; 22. Syritta pipiens *L.*; 23. Syrphus ribesii *L.*, freq. (*e*) *Tipulidae*: 24. Boletina sp., skg.; 25. Sceptonia nigra *Mg.*, do. (*f*) *Mycetophilidae*: 26. Sciara sp., freq., skg. **C. Hemiptera.** 27. Anthocoris sp., skg. **D. Hymenoptera.** *Ichneumonidae*: 28. Nine undetermined sp. **E. Lepidoptera.** *Rhopalocera*: 29. Pieris napi *L.*, skg.

1119. **P. peregrina** L.—

VISITORS.—Schletterer observed the following **Hymenoptera** at Pola.—

(*a*) *Evaniidae*: 1. Gasteruption granulithorax *Tourn.* (*b*) *Ichneumonidae*: 2. Angitia armillata *Gr.*; 3. Linoceras macrobatas *Gr.*, var. geniculata *Krchb.*; 4. Mesoleius cruralis *Gr.* (*c*) *Tenthredinidae*: 5. Cephus (Philoecus) parreyssini *Spin.*

336. Berula Hoffm.

1120. **B. angustifolia** Mert. et Koch (= Sium erectum *Huds.*).—All the umbels of this species bear hermaphrodite flowers; some of those in the middle of the umbellules frequently possess three styles (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896).

337. Sium L.

1121. **S. latifolium** L. (Herm. Müller, 'Fertilisation,' p. 276, 'Weit. Beob.,' I, p. 304; Schulz, 'Beiträge,' I, p. 44, II, p. 190; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 325; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 155.)—Schulz describes this species as andromonoecious, with markedly protandrous hermaphrodite flowers; the umbels of higher order are chiefly or entirely male. According to Kerner, the hermaphrodite flowers open first, and are distinctly protandrous; their stigmas are dusted, after the anthers have dropped off, by the crumbling masses of pollen which fall from the male flowers of the later developed lateral umbels. Geitonogamy is thus automatically effected. Warnstorf says that at Ruppin the umbellules of the primary and secondary umbels bear hermaphrodite flowers; those of tertiary umbels hermaphrodite and central male ones, or male flowers only.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

H. de Vries (Netherlands), the honey bee. MacLeod (Flanders), 3 short-tongued Hymenoptera, 4 hover-flies, 4 other Diptera, and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 267). Knuth (North Frisian Islands), 2 hover-flies and a Muscid: (Rügen).—**A. Coleoptera.** *Telephoridae*: 1. Cantharis fulva *Scop.* **B. Diptera.** (*a*) *Muscidae*: 2. Aricia sp.; 3. Graphomyia maculata *Scop.* ♀. (*b*) *Stratiomyidae*: 4. Odontomyia viridula *F.*; 5. Stratiomys furcata *F.* ♀. **C. Hymenoptera.** *Sphegidae*: 6. Gorytes quadrifasciatus *F.* ♂. Alfken (Bremen), the Ichneumonid Amblyteles laminatorius *F.* Kohl (Tyrol), the fossorial wasp Crabro scutellatus *Schev.*

Herm. Müller gives the following list.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella quatuordecimpunctata *L.*, nect-lkg. (*b*) *Mordellidae*: 2. Mordella fasciata *F.* (*c*) *Scarabaeidae*: 3. Trichius fasciatus *L.* (*d*) *Telephoridae*: 4. Telephorus melanurus *F.* **B. Diptera.** (*a*) *Dolichopodidae*: 5. Dolichopus aeneus *Deg.* (*b*) *Empidae*: 6. Empis sp. (*c*) *Muscidae*: 7. Aricia incana *Wied.*, numerous; 8. Calliphora vomitoria *L.*; 9. Cyrtoneura simplex *Loew*; 10. Lucilia caesar *L.*; 11. L. cornicina *F.*; 12. L. sylvarum *Mg.*; 13. Mesembrina meridiana *L.*, skg.; 14. Musca corvina *F.*; 15. Ocyptera brassicaria *F.*; 16. Sepsis sp.; 17. Tetanocera ferruginea *Fall.*; 18. Tephritis pantherina *Fall.*, nect-lkg., 2 individuals. (*d*) *Syrphidae*: 19. Eristalis aeneus *Scop.*; 20. E. arbustorum *L.*; 21. E. nemorum *L.*; 22. Helophilus floreus *L.*; 23. Syritta pipiens *L.*; 24. Syrphus ribesii *L.* (*e*) *Stratiomyidae*: 25. Stratiomys riparia *Mg.* **C. Hemiptera.** 26. One small sp. of Anthocoris. **D. Hymenoptera.** (*a*) *Apidae*: 27. Prosopis variegata *F.*, nect-lkg. (*b*) *Ichneumonidae*: 28. Numerous species. (*c*) *Sphegidae*: 29. Crabro dives *H.-Sch.* ♂; 30. C. lapidarius *Pz.* ♂ and ♀, freq.; 31. C. scutellatus *Schev.* ♂; 32. C. vagus *L.* ♂; 33. Gorytes quadrifasciatus *F.* ♂, skg.; 34. Oxybelus uniglumis *L.*, do. (*d*) *Tenthredinidae*: 35. Allantus arcuatus *Forst.*; 36. Athalia rosae *L.*; 37. Selandria serva *F.*

338. Conopodium Koch.

1122. C. denudatum Koch.—This is a white-flowered species.

VISITORS.—MacLeod (Pyrenees) observed 5 Hymenoptera, 2 beetles, 17 flies, and 2 Lepidoptera.

339. Bupleurum L.

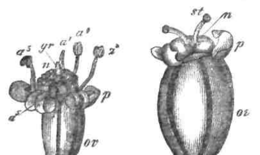


FIG. 163. *Bupleurum stellatum* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Ditto, in the second (female) stage. (×7.) a^1–a^5, anthers; *gr*, style; *n*, nectary; *ov*, ovary; *p*, petal; *st*, stigma.

1123. B. stellatum L. (Herm. Müller, 'Alpenblumen,' pp. 117–18.)—The protandry of this species is so well marked that the whole umbel is at first entirely male, afterwards entirely female. Self-pollination is therefore excluded.

VISITORS.—Herm. Müller noticed 8 Diptera and 3 Hymenoptera.

1124. B. ranunculoides L. (Kirchner, 'Beiträge,' p. 31.)—The orange-yellow blossoms of this species, which later on turn to a brownish-yellow colour, are distinctly protandrous at Zermatt. Only hermaphrodite flowers have been observed.

1125. **B. longifolium** L.—Schulz ('Beiträge,' I, p. 46) states that in this species the petals are completely involute in the bud (as in all other German species of the genus), so that the nectaries are exposed. The anthers with their incurved filaments are also uncovered in the bud. The petals usually remain in this condition during anthesis. It is only after the anthers have dehisced that the styles develop, often very slowly (as in other species), so that a considerable time often elapses between the beginning of anthesis, and the accomplishment of pollination.

Only hermaphrodite flowers have been observed.

1126. **B. tenuissimum** L.—According to Schulz (loc. cit.) the flower mechanism of this species agrees with that of B. longifolium.

1127. **B. falcatum** L.—As B. tenuissimum. The flowers are dull yellow in colour.

VISITORS.—Herm. Müller observed the following in Thuringia.—

A. Coleoptera. *Mordellidae*: 1. Mordella pumila *Cyll.*, nect-lkg., very numerous. **B. Diptera.** (*a*) *Bombyliidae*: 2. Anthrax flava, *Mg.*, skg. (*b*) *Muscidae*: 3. Gymnosoma rotundata *L.*, nect-lkg., one. (*c*) *Syrphidae*: 4. Eristalis arbustorum, *L.*, skg.; 5. Pipizella annulata *Macq.*, do.; 6. Syritta pipiens *L.*, very numerous, skg. and po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 7. Halictus interruptus *Pz.*, ♂ skg. (*b*) *Ichneumonidae*: 8. Various sp., skg. (*c*) *Tenthredinidae*: 9. Hylotoma rosae *L.*, skg. (*d*) *Vespidae*: 10. Polistes gallica *L.*, skg.; 11. P. biglumis *L.*, do.

MacLeod (Pyrenees) saw 2 Hymenoptera (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 412).

1128. **B. rotundifolium** L.—The flowers of this species are yellow, and their nectar may be seen with the naked eye as a glistening surface.

VISITORS.—Herm. Müller gives the following list for Thuringia ('Weit. Beob.,' I, p. 304).—

A. Diptera. (*a*) *Muscidae*: 1. Sp. of Anthomyia; 2. Gymnosoma rotundata *L.*; 3. Ulidia erythrophthalma *Mg.*, skg. (*b*) *Stratiomyidae*: 4. Chrysomyia formosa *Scop.* **B. Coleoptera.** *Curculionidae*: 5. Bruchus olivaceus *Germ.*, nect-lkg.; 6. Spermophagus cardui *Stev.*, do. **C. Hymenoptera.** (*a*) *Ichneumonidae*: 7. Various sp. (*b*) *Tenthredinidae*: 8. A yellow sp. (*c*) *Sphegidae*: 9. Tiphia minuta *v. d. L.*, skg. **D. Lepidoptera.** 10. Lycaena bellargus *Rott.*, skg.

340. Oenanthe L.

1129. **O. fistulosa** *L.*—According to Schulz ('Beiträge,' I, pp. 47–8), this species is andromonoecious, and the hermaphrodite flowers feebly protandrous. Purely male stocks occur here and there. The male flowers are usually at the margin, rarely in the middle of the umbellules.

VISITORS.—Herm. Müller gives the following list ('Fertilisation,' p. 281).—

A. Coleoptera. *Scarabaeidae*: 1. Trichius fasciatus *L.* **B. Diptera.** (*a*) *Empidae*: 2. Empis livida *L.*; 3. E. rustica *Fall.* (*b*) *Leptidae*: 4. Atherix ibis *F.* (*c*) *Muscidae*: 5. Sp. of Lucilia. (*d*) *Stratiomyidae*: 6. Stratiomys chamaeleon *Deg.* (*e*) *Syrphidae*: 7. Eristalis arbustorum *L.*; 8. E. nemorum *L.*; 9. E. sepulcralis *L.*; 10. Syritta pipiens *L.* **C. Hymenoptera.** *Apidae*: 11. Heriades truncorum *L.* ♀, skg.; 12. Macropis labiata *F.* ♂, do.; 13. Prosopis sp.

MacLeod (Flanders) observed a hover-fly (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 270). Schletterer (Pola) saw the Ichneumonid Tryphon rutilator *Gr.*

1130. **O. aquatica** *Poir.* (= Q. Phellandrium *Lam.*, and Phellandrium aquaticum *L.*).—Schulz ('Beiträge,' II, p. 190) states that this species is andromonoecious with protandrous hermaphrodite flowers. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes the plants growing in the neighbourhood of Ruppin as being andromonoecious. The umbellules of primary umbels bear hermaphrodite flowers, or there may be a few marginal male flowers; those of the secondary umbels may bear hermaphrodite flowers only, or marginal male and central hermaphrodite ones, or male flowers exclusively: those of the tertiary umbels are purely male.

VISITORS.—Herm. Müller observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *L.*, numerous, skg., po-dvg. (*b*) *Chrysomelidae*: 2. Prasocuris phellandrii *L.*, dvg. the flowers. (*c*) *Coccinellidae*: 3. Coccidula rufa *Hbst.*, nect-lkg. (*d*) *Elateridae*: 4. Adrastus palleus *F. Er.*, skg. **B. Diptera.** (*a*) *Muscidae*: 5. Aricia vagans *Fall.*, skg.; 6. Cyrtoneura curvipes *Macq.* (as determined by Herr Winnerz), do.; 7. Lucilia cornicina *F.* (*b*) *Mycetophilidae*: 8. Sciara thomae *L.* (*c*) *Stratiomyidae*: 9. Odontomyia viridula *F.* (*d*) *Syrphidae*: 10. Eristalis arbustorum *L.*: 11. Syritta pipiens *L.* and others. **C. Hymenoptera.** (*a*) *Apidae*: 12. Prosopis variegata *F.* ♂; 13. Sphecodes gibbus *L.* ♂. (*b*) *Ichneumonidae*: 14. Various sp. (*c*) *Scoliidae*: 15. Tiphia ruficornis *Klg.* (*d*) *Sphegidae*: 16. Oxybelus bipunctatus *Ol.* ♀; 17. Pompilus trivialis *Dahlb.* ♀; 18. P. viaticus *L.* (*e*) *Tenthredinidae*: 19. Athalia rosae *L.*; 20. Tenthredo sp. **D. Lepidoptera.** 21. Vanessa c-album *L.*

The following were recorded by the observers, and at the places stated.—

Knuth (Föhr) ('Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 234), 2 skg. hover-flies (Eristalis sp. and Syrphus sp.) and Muscids (Musca domestica *L.*, Sarcophaga carnaria *L.*, and Scatophaga stercoraria). Alfken (Bremen),—**A. Diptera.** *Syrphidae*: 1. Chrysotoxum festivum *L.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena parvula *K.* ♀. (*b*) *Sphegidae*: 3. Ceropales maculatus *F.*; 4. Crabro brevis *v. d. L.* ♀ and ♂. (*c*) *Vespidae*: 5. Odynerus parietum *L.* ♀. MacLeod (Flanders), 6 short-tongued Hymenoptera, 8 hover-flies, 3 Muscids, a beetle, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 269).

1131. **O. peucedanifolia** Pollich.—

VISITORS.—MacLeod (Flanders) observed a Tenthredinid and 3 Muscids (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 27).

1132. **O. crocata** L.—

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Scott-Elliot (Dumfriesshire), a humble-bee, a short-tongued bee, a wasp, 5 hover-flies, and 4 Muscids ('Flora of Dumfriesshire,' p. 78). Loew (Berlin Botanic Garden), 2 hover-flies (Syritta pipiens *L.* and Syrphus ribesii *L.*), skg.

341. Aethusa L.

1133. **A. Cynapium** L. (Herm. Müller, 'Weit. Beob.,' I, p. 305; Schulz, 'Beiträge,' II, pp. 84, 90–1; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 342, 344; Warnstorf. Verh. bot. Ver., Berlin, xxxv, 1895; Knuth, 'Bl. ü. Insekt. u. d. nordfr. Ins.,' p. 155.)—According to Schulz, the hermaphrodite flowers of this species are slightly protandrous or homogamous, but Kerner describes them as protogynous. Automatic self-pollination regularly takes place, as a result of the filaments bending inwards.

Warnstorf says that at Ruppin either all the umbels are purely hermaphrodite, or the tertiary ones bear marginal hermaphrodite and central male flowers.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands), 5 Syrphids, 2 Muscids, and a beetle. Buddeberg (Nassau),—**A. Diptera.** *Syrphidae*: 1. Ascia podagrica *F.*, po-dvg., very numerous; 2. Helophilus floreus *L.*, nect-lkg. and po-dvg.; 3. Paragus cinctus *Schiner et Egg.*, nect-lkg. **B. Hymenoptera.** All nect-lkg. (*a*) *Apidae*: 4. Prosopis communis *Nyl.* ♀; 5. P. obscurata *Schenck* (=P. punctulatissima *Sm.*) ♂; 6. P. signata *Pz.* ♂; 7. P. sinuata *Schenck* ♂. (*b*) *Sphegidae*: 8. Crabro vexillatus *Pz.* ♂. 9. Pompilus concinnus *Dahlb.* ♀. (*c*) *Tenthredinidae*: 10. Allantus temulus *Scop. L.* MacLeod (Flanders) 4 hover-flies, 2 Muscids, and Trombidium (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 271, 280). Sickmann (Osnabrück) the fossorial wasp Pemphredon lugubris *Ltr.*

342. Foeniculum Tourn.

1134. **F. vulgare** Mill. (=F. capillaceum *Gilib.*, F. officinale *All.*, and Anethum Foeniculum *L.*)—According to Schulz ('Beiträge,' II, pp. 84, 190), the small yellow flowers of this species are andromonoecious, the hermaphrodite ones being markedly protandrous. Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 325) says that these protandrous flowers are the first to bloom, and after their stamens have dropped off are geitonogamously crossed by crumbling masses of pollen, which fall from the later maturing male flowers of adjacent lateral umbels.

Visitors.—These were recorded by the observers, and for the localities stated.—

Loew (Berlin Botanic Garden), a true wasp, Eumenes coarctatus *L.* Kohl (Tyrol), 4 Chrysidids (1. Chrysis scutellaris *F.*; 2. C. distinguenda *Spin.*; 3. Stilbum cyanurum *Forst.*, var. calens *F.*; 4. Hedychrum roseum *Rossi*) and 10 true wasps (1. Vespa germanica *F.*; 2. V. holsatica *F.*; 3. Polistes gallica *L.*; 4. Eumenes pomiformis *F.*; 5. E. unguiculata *Vill.*; 6. Odynerus sinuatus *F.*; 7. O. bifasciatus *L.*; 8. O. parvulus *Lep.*; 9. O. bidentatus *Lep.*; 10. O. modestus *Sauss.*). Handlirsch the fossorial wasp Gorytes pleuripunctata *Costa.* Schletterer and von Dalla Torre (Tyrol), 4 bees (1. Halictus albipes *F.*; 2. H. costulatus *Kirchb.* ♂; 3. H. sexcinctus *F.*; 4. H. vulpinus *Nyl.*).

343. Seseli L.

1135. **S. Hippomarathrum** Jacq.—Schulz ('Beiträge,' I, p. 49) states that the umbels of this species develop very slowly. Only protandrous hermaphrodite flowers have been observed. Some tertiary umbels do not set fruits.

1136. **S. annuum** L.—In this species again, Schulz (loc. cit.) only observed protandrous hermaphrodite flowers.

344. Libanotis Riv.

1137. **L. montana** Crantz (=Athamanta Libanotis *L.*, and Seseli Libanotis *Koch*).—Schulz ('Beiträge,' I, p. 49) found only hermaphrodite flowers in primary and secondary umbels. Tertiary ones (not always present) are often purely male. According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 511), the petals are white in the lowlands, but reddish-violet on the under-side in plants growing on Alpine heights. In Hohenzollern the flowers are tinged with yellow, and rather fragrant.

VISITORS.—X. Rieber, quoted by Kirchner, gives the following list for the neighbourhood of Haigerloch in Hohenzollern (Jahreshefte Ver. Natk., Stuttgart, xlviii, 1892).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura testacea *L.*; 2. Molorchus minor *L.*; 3. Strangalia bifasciata *Müll.*; 4. S. melanura *L.*; 5. S. quadrifasciata *L.* (*b*) *Scarabaeidae*: 6. Cetonia aurata *L.* **B. Diptera.** 7. 33 different flies, the species of which cannot be given with certainty. **C. Hemiptera.** (Carnivorous forms not seeking for pollen or nectar): *Pentatomidae*: 8. Carpocoris nigricornis *F.*; 9. Eurydema festivum *L.*; 10. E. oleraceum *L.*; 11. Eurygaster hottentotta *H.-Sch.*; 12. Graphosoma lineatum *L.*; 13. Palomena prasina *L.*; 14. Tropicoris rufipes *L.* **D. Hymenoptera.** (*a*) *Apidae*: 15. Andrena hattorfiana *F.*; 16. Coelioxys rufescens *Lep.*; 17. Nomada lineola *Pz.*; 18. N. ochrostoma *K.* (*b*) *Ichneumonidae*: 19. Amblyteles negatorius *F.*; 20. A. palliatorius *Gr.*; 21. Caenocryptus bimaculatus *Grav.*; 22. Ichneumon sarcitorius *L.* (*c*) *Tenthredinidae*: 23. Allantus arcuatus *Forst.*; 24. A. schaefferi *Klg.*; 25. A. vespa *Retz.*; 26. Macrophyia albicincta *Schr.*; 27. M. militaris *Klg.*; 28. M. diversipes *Schr.*; 29. Tenthredo fagi *Pz.*; 30. T. flava *Poda*; 31. T. dispar *Klg.* (*d*) *Vespidae*: 32. Odynerus parietum *L.*; 33. Polistes gallica *L.* **E. Lepidoptera.** *Rhopalocera*: 34. Argynnis paphia *L.*; 35. Limenitis sibylla *L.*; 36. Melanargia galatea *L.*; 37. Syrichthus alveus *Hb.*; 38. Thecla quercus *L.*; 39. Vanessa io *L.*

Kohl (Tyrol) observed the true wasp Odynerus parietum *L.*, and also the fossorial wasp Crabro rhaeticus *Aich. et Krchb.*

MacLeod (Pyrenees) noticed 5 short-tongued Hymenoptera, a Lepidopterid, 3 beetles, and 9 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 412).

345. Cnidium Cusson.

1138. **C. venosum** Koch (Seseli venosum *Hoffm.* and Selinum sylvestre *L.*).—Schulz ('Beiträge,' I, p. 49) describes this species as andromonoecious. In some places all the flowers are hermaphrodite, in others the secondary umbels usually bear some male flowers or, rarely, may be purely male.

346. Athamanta L.

1139. **A. cretensis** L.—According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 296), there is a central hermaphrodite flower in every umbel of this species, surrounded by pseudo-hermaphrodite male flowers, and these again by hermaphrodite ones.

347. Silaus Bernh.

1140. **S. pratensis** Bess. (= S. flavescens *Bernh.*, Peucedanum silaus *L.*, and Seseli pratense *Crantz*).—Schulz ('Beiträge,' I, p. 49) observed only hermaphrodite flowers in this species.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller ('Fertilisation,' p. 282), a bee (Halictus longulus *Sm.* ♂, skg.), a Pompilid (Pompilus viaticus *L.* ♂, nect-lkg.), and a saw-fly (Allantus nothus *Klg.*). Krieger (Leipzig), the fossorial wasp Mellinus sabulosus *F.* ♀. Kohl (Tyrol), 2 true wasps (Odynerus parietum *L.*, and O. trifasciatus *F.*).

348. Meum Adans.

1141. **M. athamanticum** Jacq.—Schulz ('Beiträge, II, pp. 84–5, 190) describes this species as andromonoecious, with markedly protandrous hermaphrodite flowers.

1142. **M. Mutellina** Gaertn. (=Phellandrium Mutellina *L.*). (Ricca, Atti Soc. ital. sc. nat., Milano, xiv, 1871; Herm. Müller, 'Alpenblumen,' pp. 116–20; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 296; Schröter, 'Beiträge zur Kennt. schweiz. Blütenpfl.')—The flowers of this species are rose-red or dark carmine-red in colour, and smell like honey. Schröter states that there are male flowers as well as the markedly protandrous hermaphrodite ones. The two kinds are usually associated on the same stocks, but a few plants are purely male. Kerner describes the umbels as possessing an intermediate zone of pseudo-hermaphrodite male flowers.

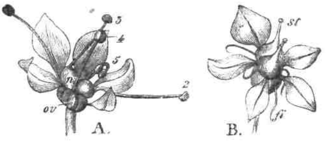


FIG. 164. *Meum Mutellina*, *Gaertn.* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Ditto, in the second (female) stage. 1–5, stamens; *fi*, filament; *n*, nectary; *ov*, ovary; *st*, stigma.

VISITORS.—Herm. Müller observed 5 beetles, 32 Diptera, 5 Hymenoptera, and 9 Lepidoptera in the Alps.

349. Pachypleurum Ledeb.

1143. **P. alpinum** Ledeb.—Ekstam describes the flowers of this species in Nova Zemlia as being markedly protandrous, sometimes protogynous-homogamous; their odour resembles that of elder, and their diameter is 1·5–2 mm.

VISITORS.—Flies have been observed by Ekstam in Nova Zemlia.

350. Crithmum L.

1144. **C. maritimum** L. (Kirchner, 'D. Blüten d. Umbelliferen.')—Kirchner states that in this species the protandry characteristic of Umbelliferae is extremely well marked. The small flowers (only about 2 mm. in diameter) possess yellowish-white petals, which are permanently involute. The stamens, that also are at first incurved, diverge as usual during dehiscence, after which they wither and fall off with the petals. The two styles now develop, though in the male stage no trace of them was recognizable; they are very short. An umbel does not as a rule pass into the female stage till all the stamens and petals have dropped off, so that insect-visits necessarily bring about crossing between different umbels. Owing to the white colour of the disks, umbels in the female stage appear of a whitish-green, and are less conspicuous than during the preceding male stage.

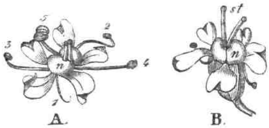
VISITORS.—The following were recorded by the observers, and for the localities stated.—

Kirchner (on the Lido near Venice), flies. Plateau (Ghent Botanic Garden), Musca domestica *L.*, and a small bug (Miris sp.).

351. **Gaya** Gaud.

1145. **G. simplex** Gaud.—Schulz ('Beiträge') describes this species as andromonoecious, with protandrous hermaphrodite flowers. According to Hermann Müller ('Alpenblumen,' p. 120), the flower mechanism agrees with that of Meum Mutellina.

VISITORS.—Herm. Müller saw 8 Diptera.



A. B.

FIG. 165. *Gaya simplex, Gaud.* (after Herm. Müller). *A.* Flower in the first (male) stage. *B.* Ditto, in the second (female) stage. 1-5, stamens; *n*, nectary; *st*, stigma.

352. **Conioselinum** Fisch.

1146. **C. tartaricum** Hoffm. (=C. Fischeri *Wimm. et Grab.*, and Selinum Gmelini *Bray*).—Schulz ('Beiträge,' II, p. 190) describes this species as andromonoecious, with protandrous hermaphrodite flowers.

Loew (Berlin Botanic Garden) observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., skg.; 2. Chloria demandata *F.*; 3. Pyrellia cadaverina *L.*; 4. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 5. Eristalis arbustorum *L.*, skg.; 6. E. nemorum *L.*; 7. E. tenax *L.*, skg.; 8. Helophilus floreus *L.*, do.; 9. Syritta pipiens *L.*, do. **B. Hymenoptera.** *Sphegidae*: 10. Oxybelus bipunctatus *Oliv.*, ♀ and ♂.

353. **Levisticum** Riv.

1147. **L. officinale** Koch (=Ligusticum Levisticum *L.*).—

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Loew (Berlin Botanic Garden),—**A. Diptera.** (*a*) *Muscidae*: 1. Anthomyia sp., skg. (*b*) *Syrphidae*: 2. Helophilus trivittatus *F.*; 3. Syrphus pyrastri *L.*, skg. **B. Hymenoptera.** (*a*) *Apidae*: 4. Apis mellifica *L.* ☿, skg. and po-cltg. (*b*) *Sphegidae*: 5. Crabro cribrarius *L.* ♂. von Dalla Torre (Tyrol), the humble-bee Bombus terrester *L.* Kohl (Tyrol), the true wasp Ancistrocerus parietum *L.*

354. **Ligusticum** L.

1148. **L. pyrenaicum** Gouan.—

VISITORS.—The following were recorded by the observers, and for the localities stated.—

MacLeod (Pyrenees), 17 short-tongued Hymenoptera, 16 Syrphids, 26 Muscids and Empids. Loew (Berlin Botanic Garden), a hover-fly (Eristalis arbustorum *L.*).

1149. **L. commutatum** Regel.—

VISITORS.—Loew saw a humble-bee (Bombus terrester *L.* ☿), skg., in the Berlin Botanic Garden.

355. **Selinum** L.

1150. **S. pyrenaeum** Gouan (=Angelica pyrenaea *Spreng.*).—This species bears flowers of a greenish colour.

VISITORS.—MacLeod (Pyrenees) saw a beetle and 2 flies.

1151. **S. Carvifolia** L. (=Angelica Carvifolia *Vill.*).—Schulz ('Beiträge,' I, p. 49, II, p. 190) describes this species as andromonoecious, with markedly protandrous hermaphrodite flowers, many of which do not attain maturity. The secondary umbels are often purely male. According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), the umbellules of primary umbels bear hermaphrodite flowers at Ruppin; secondary ones marginal hermaphrodite and central male flowers.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Loew (Switzerland) ('Beiträge,' p. 56), Ichneumonids (undetermined sp.) and a saw-fly (Tenthredo sp.). Sickmann (Osnabrück), the parasitic fossorial wasp Ceropales maculatus *F.*

356. Ostericum Hoffm.

1152. **O. palustre** Bess. (=O. pratense *Hoffm.*, and Angelica pratensis *Bieb.*).—Schulz describes this species as andromonoecious, with protandrous hermaphrodite flowers.

357. Angelica L.

1153. **A. sylvestris** L. (Schulz, 'Beiträge,' I, p. 50.)—Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) states that the umbellules of primary and secondary umbels bear hermaphrodite flowers at Ruppin; tertiary ones marginal hermaphrodite and central male flowers. Sometimes all the umbels are female by degeneration of the anthers.

VISITORS.—Herm. Müller gives the following list ('Fertilisation,' p. 282; 'Weit. Beob.,' I, p. 305).—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella septempunctata *L.*, skg.; 2. C. quattuordecimpunctata *L.*, do. (*b*) *Dermestidae*: 3. Anthrenus pimpinellae *F.* (*c*) *Nitidulidae*: 4. Meligethes, freq. (*d*) *Scarabaeidae*: 5. Trichius fasciatus *L.*, nect-lkg. (*e*) *Telephoridae*: 6. Telephorus melanurus *F.* **B. Diptera.** (*a*) *Muscidae*: 7. Echinomyia fera *L.*; 8. Lucilia sylvarum *L.*; 9. Mesembrina meridiana *L.*; 10. Sarcophaga sp.; 11. Scatophaga merdaria *F.*; 12. S. stercoraria *L.*; 13. Tachina larvarum *L.* (*b*) *Syrphidae*: 14. Eristalis pertinax *Scop.*; 15. Helophilus floreus *L.*; 16. Pipizella virens *F.*; 17. Syritta pipiens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 18. Andrena pilipes *F.* ♀; 19. Sp., skg. (*b*) *Evaniidae*: 20. Foenus affectator *F.* (*c*) *Ichneumonidae*: 21. Various species. (*d*) *Sphegidae*: 22. Crabro lapidarius *Pz.*, ♂ and ♀, freq.; 23. Philanthus triangulum *F.* (*e*) *Tenthredinidae*: 24. Athalia rosae *L.*; 25. Species of Tenthredo. (*f*) *Vespidae*: 26. Odynerus debilitatus *Sauss.*; 27. Vespa rufa *L.* ☿, skg. **D. Lepidoptera.** 28. Argynnis paphia *L.* (skg.?). **E. Neuroptera.** 29. Panorpa communis *L.*, nect-lkg.—And (in the Alps), 4 beetles, a Muscid, and 2 wasps ('Alpenblumen,' p. 120).

Alfken observed the following at Bremen.—

A. Diptera. (*a*) *Therevidae*: 1. Thereva nobilitata *F.*, skg. (*b*) *Muscidae*: 2. Cyrtoneura hortorum *Fall.*, freq.; 3. Frontina laeta *Mg.*; 4. Graphomyia maculata *Scop.*, freq.; 5. Nemoraea radicum *F.*, do.; 6. Onesia sepulcralis *Mg.*, do. (*c*) *Syrphidae*: 7. Cheilosia variabilis *Pz.*; 8. Chrysotoxum bicinctum *L.* ♀; 9. Eristalis intricarius *L.*, very common; 10. Sericomyia borealis *Fall.*; 11. Syrphus balteatus *Deg.*, do.; 12. S.

corollae *F.*, do.; 13. S. pyrastri *L.*, freq.; 14. Volucella bombylans *L.* **B. Hymenoptera.** (*a*) *Ichneumonidae*: 15. Amblyteles occisorius *F.*; 16. Banchus falcator *F.*, rare; 17. Metopius micratorius *Gr.*; 18. Ophion ramidulus *Gr.*; 19. Phygadenon cephalotes *Gr.* (*b*) *Sphegidae*: 20. Crabro cribrarius *L.* ♀ and ♂, very common; 21. C. fuscitarsis *H.-Sch.* ♀, very rare; 22. C. vagus *L.* ♀, very common. (*c*) *Tenthredinidae*: 23. Abia sericea *L.*, rare. (*d*) *Vespidae*: 24. Odynerus parietum *L.* ♂, very common; 25. O. sinuatus *F.* ♂, rare.

Loew gives the following for the Riesengebirge ('Beiträge,' p. 47).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Pachyta octomaculata *F.*; 2. P. quadrimaculata *L.*; 3. Strangalia armata *Hbst.* (*b*) *Scarabaeidae*: 4. Trichius fasciatus *L.* **B. Diptera.** (*a*) *Muscidae*: 5. Echinomyia fera *L.*; 6. E. grossa *L.* (*b*) *Mycetophilidae*: 7. Sciara thomae *L.* (*c*) *Syrphidae*: 8. Eristalis nemorum *L.*; 9. Syrphus cinctellus *Zett.* ♂; 10. S. glaucius *L.*; 11. Volucella pelluceus *L.* **C. Hymenoptera.** (*a*) *Apidae*: 12. Psithyrus rupestris *F.* ♀, skg. (*b*) *Tenthredinidae*: 13. Rhogogastera viridis *L.* (*c*) *Vespidae*: 14. Vespa rufa *L.* ☿, skg. **D. Neuroptera.** 15. Panorpa communis *L.* And for Switzerland (op. cit., p. 55),—**A. Diptera.** *Tabanidae*: 1. Tabanus infuscatus *Lw.* (?). **B. Hymenoptera.** *Sphegidae*: 2. Crabro cribrarius *L.* ♀; 3. Gorytes campestris *Müll.*

The following were recorded by the observers, and for the localities stated.—

Handlirsch, 3 fossorial wasps (1. Gorytes bicinctus *Rossi*; 2. G. quadrifasciatus *F.*; 3. G. quinquecinctus *F.*). Von Dalla Torre (Tyrol), the true wasp Leionotus minutus *F.* Sickmann (Osnabrück),—**A. Hymenoptera.** (*a*) *Sphegidae*: 1. Ceropales maculatus *F.*, occasional; 2. Crabro cribrarius *L.*, very common; 3. C. dives *H.-Sch.*, rare; 4. C. sexcinctus *v. d. L.*, freq.; 5. C. vagus *L.*, very common; 6. Gorytes bicinctus *Rossi*, a ♂; 7. G. laticinctus *Schuck.*, infrequent; 8. G. quadrifasciatus *F.*; 9. G. quinquecinctus *F.*, rare; 10. Mellinus sabulosus *F.*; 11. Mimesa atra *Pz.*; 12. Pemphredon unicolor *F.* H. de Vries (Netherlands) (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875), a bee (Apis mellifica *L.* ☿), a humble-bee (Bombus terrester *L.* ☿), a parasitic humble-bee (Psithyrus vestalis *Fourcr.* ♀), a true wasp (Vespa germanica *F.* ☿), and a fossorial wasp (Crabro vagus *L.* ♀). MacLeod (Flanders), Apis, 9 short-tongued Hymenoptera, 10 hover-flies, 11 other flies, 2 beetles, and Panorpa (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 273–4, 380); (Pyrenees), 8 Hymenoptera, 5 beetles, and 4 flies (op. cit., iii, 1891, pp. 407–8). Lindman (Dovrefjeld), numerous flies, and several bees.

Willis records the following for the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Diptera. (*a*) *Chironomidae*: 1. Chironomus sp., skg.; 2. C. (Cricotopus) tremulus *L.*, do. (*b*) *Muscidae*: 3. Anthomyia radicum *L.*, skg.; 4. A. sp., do.; 5. Caricea tigrina *F.*, do.; 6. Aricia incana *Wied.*, do.; 7. A. lucorum *Fall.*, freq., skg.; 8. Lucilia caesar *L.*, do.; 9. L. sericata *Mg.*, do.; 10. Cyrtoneura curvipes *Mcq.*, do.; 11. Mydaea sp.; 12. Myobia inanis *Fall.*; 13. Sarcophaga sp.; 14. Scatophaga stercoraria *L.*; 15. Spilogaster communis *R.-D.* (*c*) *Mycetophilidae*: 16. Glaphyroptera fasciola *Mg.*; 17. Sceptonia nigra *Mg.* (*d*) *Phoridae*: 18. Phora sp. (*e*) *Syrphidae*: 19. Cheilosia oestracea *L.*; 20. Eristalis horticola *Deg.*; 21. E. pertinax *Scop.*, freq.; 22. Platycheirus peltatus *Mg.* **B. Hemiptera.** 23. Anthocoris sp.; 24. Calocoris fulvomaculatus *Deg.* **C. Hymenoptera.** (*a*) *Apidae*: all skg.: 25. Bombus terrester *L.*; 26. Halictus rubicundus *Chr.*; 27. Prosopis brevicornis *Nyl.*; all skg. (*b*) *Ichneumonidae*: 28. Eight undetermined species. (*c*) *Tenthredinidae*: 29. Selandria serva *F.* (*d*) *Vespidae*: 30. Vespa sylvestris *Scop.*, freq. **D. Lepidoptera.** *Rhopalocera*: 31. Polyommatus phlaeas *L.*, skg.

358. Archangelica Hoffm.

1154. **A. officinalis** Hoffm. (= Angelica Archangelica *L.*).—The hermaphrodite flowers of this species are markedly protandrous in the Tyrol and Central Germany (Schulz, 'Beiträge,' II, p. 190); also in Greenland (Warming). In the former regions the species is andromonoecious, and the secondary umbels are partly male, the tertiary ones entirely so.

Plateau observed the following insects as common visitors.—

Bees (Apis; Odynerus quadratus *Pz.*), a Chrysidid (Chrysis ignita *L.*), and Muscids (Calliphora; Musca; Lucilia).

359. Peucedanum L.

1155. **P. Cervaria** Cusson.—Schulz ('Beiträge,' II, pp. 50–1) states that this species is andromonoecious, with protandrous hermaphrodite flowers; sometimes these latter preponderate, sometimes the male flowers do so. The secondary umbels may bear male flowers only, hermaphrodite ones only, or both. When tertiary umbels occur they are purely male.

Visitors.—Herm. Müller observed the following in Thuringia ('Fertilisation,' p. 282).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia bifasciata *Müller*. (*b*) *Chrysomelidae*: 2. Clythra scopolina *L.* **B. Diptera.** (*a*) *Bombyliidae*: 3. Anthrax maura *L.* (*b*) *Muscidae*: 4. Gymnosoma rotundata *L.*, very numerous; 5. Phasia analis *F.*, one; 6. P. crassipennis *F.*, freq. **C. Hymenoptera.** (*a*) *Apidae*: 7. Andrena minutula *K.* ♀, numerous, po-cltg.; 8. Halictus leucozonius *Schr.* ♂ and ♀, skg. and po-cltg.; 9. H. quadricinctus *F.* ♀, skg.; 10. Megachile lagopoda *L.* ♀, on one occasion, skg. (*b*) *Chrysididae*: 11. Hedychrum lucidulum *F.* ♂ and ♀. (*c*) *Sphegidae*: all nect-lkg.; 12. Ammophila sabulosa *L.*; 13. Ceropales maculata *F.* ♀; 14. C. variegata *F.* ♀ and ♂; 15. Crabro cribrarius *L.* ♀ and ♂, freq.; 16. C. vagus *L.* ♀; 17. Nysson maculatus *F.* ♀; 18. Pompilus viaticus *L.* ♂; 19. Priocnemis bipunctatus *F.* ♀; 20. P. obtusiventris *Schjödte* ♀; 21. Psammophila viatica *L.* ♂; 22. Tachysphex nitidus *Spin.* ♀; 23. T. pectinipes *L.* ♀; 24. Tiphia femorata *F.*, very numerous. (*d*) *Vespidae*: 25. Polistes biglumis *L.*; 26. P. gallica *L.*

Kohl records the fossorial wasp Crabro cribrarius *L.* ♀ and ♂, freq., for the Tyrol.

Loew saw the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Graphomyia maculata *Scop.* (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*, skg.; 3. E. nemorum *L.*, do.; 4. E. tenax *L.*, do. **B. Hymenoptera.** (*a*) *Apidae*: 5. Prosopis sp. ♀, skg. (*b*) *Tenthredinidae*: 6. Allantus viennensis *Pz.*

1156. **P. Oreoselinum** Moench (= Athamanta Oreoselinum *L.*).—Schulz ('Beiträge,' I, p. 52) describes this species as andromonoecious, with markedly protandrous hermaphrodite flowers, and, as a rule, a relatively large number of male ones. The primary umbels usually contain hermaphrodite flowers, rarely male ones only. In the latter case secondary umbels are exclusively hermaphrodite. Tertiary umbels, when present, are male. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) found the primary umbels to be hermaphrodite at Ruppin, while the others were almost always male, their umbellules only now and then possessing a few marginal hermaphrodite flowers.

VISITORS.—Loew observed the following in Brandenburg (B.) and Mecklenburg (M.) ('Beiträge,' p. 37).—

A. Coleoptera. (*a*) *Alleculidae*: 1. Cteniopus sulphureus *L.* (*b*) *Oedemeridae*: 2. Oedemera flavescens *L.* ♂ (B.); 3. O. flavipes *F.* ♂ (B.); 4. O. lurida *Marsh.* (B.); 5. O. subulata *Oliv.* ♀ (B.); 6. O. podagrariae *L.* (B.); 7. O. virescens *L.* (B.). (*c*) *Telephoridae*: 8. Dasytes flavipes *F.* (B.); 9. Rhagonycha melanura *F.* (B.). **B. Diptera.** (*a*) *Muscidae*: 10. Cynomyia mortuorum *L.* (M.); 11. Exorista lucorum *Mg.* (M.); 12. Olivieria lateralis *F.* (M.). (*b*) *Syrphidae*: 13. Eumerus ovatus *Lw.* ♀ (M.). **C. Hymenoptera.** (*a*) *Apidae*: 14. Colletes daviesanus *K.* ♀, skg. (M.); 15. C. fodiens *K.* ♀, do. (M.). (*b*) *Ichneumonidae*: 16. Undetermined species (B.). (*c*) *Scoliidae*: 17. Tiphia minuta *v. d. L.* ♀ (B.). (*d*) *Vespidae*: 18. Odynerus trifasciatus *F.* (M.). Also in Switzerland (op. cit., p. 56).—**A. Coleoptera.** (*a*) *Cleridae*: 1. Trichodes apiarius *L.* (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.*, var. lucidula; 3. Hoplia praticola *Duft.* **B. Diptera.** (*a*) *Muscidae*: 4. Ocyptera brassicaria *F.* (*b*) *Stratiomyidae*: 5. Stratiomys chamaeleon *Deg.*; 6. S. longicornis *Scop.* (*c*) *Syrphidae*: 7. Syrphus diaphanus *Zett.* (?). (*d*) *Tabanidae*: 8. Tabanus bromius *L.*; 9. T. infuscatus *Lw.* **C. Hymenoptera.** *Tenthredinidae*: 10. Allantus viduus *Ross.*; 11. Hylotoma berberidis *Schr.*; 12. Tenthredo sp.

Herm. Müller (Kitzingen) saw the hawk-moth Zygaena meliloti *Esp.*, skg. or attempting to do so. Rössler (Wiesbaden) noticed a Tineid: Chauliodus iniquellus *Wck.*

1157. **P. officinale** L.—Schulz ('Beiträge,' II, p. 190) describes this species as andromonoecious, with protandrous hermaphrodite flowers.

1158. **P. venetum** Koch.—According to Schulz ('Beiträge,' II, pp. 85, 90), the hermaphrodite flowers of this species are strongly protandrous. He did not observe any purely male ones.

1159. **P. alsaticum** L.—Schulz ('Beiträge, II, p. 190) describes this species as andromonoecious, with protandrous hermaphrodite flowers.

1160. **P. palustre** Moench (= Selinum palustre *L.*, and Thysselinum palustre *Hoffm.*).—As P. alsaticum (Schulz, loc. cit.).

VISITORS.—Herm. Müller observed the following visitors at Lippstadt ('Weit. Beob.,' I, p. 306).—

A. Diptera. (*a*) *Bibionidae*: 1. Dilophus vulgaris *Mg.* freq. (*b*) *Muscidae*: 2. Aricia sp.; 3. Sepsis sp. (*c*) *Syrphidae*: 4. Eristalis arbustorum *L.*, nect-lkg.; 5. Helophilus floreus *L.* **B. Coleoptera.** *Telephoridae*: 6. Dasytes flavipes *F.*, nect-lkg.; 7. Telephorus melanurus *F.*, do. **C. Hymenoptera.** (*a*) *Ichneumonidae*: 8. Various species. (*b*) *Sphegidae*: 9. Crabro brevis *v. d. L.* ♂, in great numbers, skg. (*c*) *Apidae*: 10. Prosopis clypearis *Schenck* ♂, skg.

Loew noticed the following in Silesia ('Beiträge,' p. 30).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia armata *Hbst.* (*b*) *Telephoridae*: 2. Dasytes flavipes *F.*, nect-lkg. (*c*) *Nitidulidae*: 3. Meligethes sp. **B. Diptera.** *Syrphidae*: 4. Eristalis arbustorum *L.*, skg. **C. Lepidoptera.** *Rhopalocera*: 5. Argynnis aglaïa *L.*, skg.; 6. A. pandora *S. V.*, do.; 7. A. paphia *L.*, do.

1161. **P. Ruthenicum** Bieb.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella bipunctata *L.*, nect-lkg.; 2. C. septempunctata *L.*, nect-lkg. **B. Diptera.** (*a*) *Muscidae*: 3. Anthomyia sp., skg.;

4. Chloria demandata *F.*; 5. Pyrellia cadavorina *L.*; 6. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 7. Eristalis arbustorum *L.*; 8. E. nemorum *L.*, skg.; 9. Helophilus floreus *L.*, skg.; 10. Syritta pipiens *L.*, skg. **C. Hymenoptera.** (*a*) *Apidae*: 11. Prosopis armillata *Nyl.* ♀, skg.; 12. P. sp. ♀, skg. (*b*) *Sphegidae*: 13. Crabro vexillatus *Pz.* ♀; 14. Oxybelus bipunctatus *Oliv.* ♀ and ♂.

360. Tommasinia Bertol.

1162. **T. verticillaris** Bertol. (=Peucedanum verticillare *Spreng.*).—

Visitors.—Loew observed the following in the Berlin Botanic Garden ('Blütenbiol. Floristik,' p. 242).—

A. Coleoptera. *Telephoridae*: 1. Anthocomus equestris *F.*, nect-lkg. **B. Diptera.** *Syrphidae*: 2. Eristalis nemorum *L.*, skg. **C. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.

361. Ferulago Koch.

1163. **F. monticola** Boiss. et Heldr. (=Ferula monticola *Nym.*).—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella septempunctata *L.* (*b*) *Dermestidae*: 2. Anthrenus scrophulariae *L.*, nect-lkg. **B. Diptera.** *Bibionidae*: 3. Bibio hortulans *L.* ♀, nect-lkg. **C. Hymenoptera.** *Tenthredinidae*: 4. Hylotoma berberidis *Schr.* ♀.

1164. **F. sylvatica** Reichb.—

Visitors.—Loew observed the hover-fly Syritta pipiens *L.*, skg., in the Berlin Botanic Garden.

362. Imperatoria L.

1165. **I. Ostruthium** L. (=Peucedanum Ostruthium *Koch*). According to Schulz ('Beiträge,' II, p. 190), this species is andromonoecious, with protandrous hermaphrodite flowers. Hermann Müller says that the flower mechanism resembles that of Gaya.

Visitors.—Loew observed in the Alps (Heuthal) the fly Tabanus borealis *F.* ♂ ('Blütenbiol. Floristik,' p. 396). Herm. Müller, in the Alps (foot of Piz Alv), noticed 9 beetles, 11 Diptera, 7 Hymenoptera, a Lepidopterid, and a Neuropterid ('Alpenblumen,' p. 121).

Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Dermestidae*: 1. Anthrenus scrophulariae *L.*, nect-lkg. **B. Diptera.** (*a*) *Muscidae*: 2. Lucilia caesar *L.* (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*, skg.; 4. Syritta pipiens *L.* **C. Hymenoptera.** *Apidae*: 4. Andrena schrankella *Nyl.* ♀, skg. and po-cltg.

363. Anethum Tourn.

1166. **A. graveolens** L. (=Peucedanum graveolens *Benth. et Hook. f.*).—The small yellow flowers of this species contain but little nectar, though they possess a strong odour. Schulz ('Beiträge,' II, pp. 85, 90, 91) describes them as homogamous and hermaphrodite, and says that they are visited by many insects, chiefly flies and Hymenoptera, rarely beetles. According to Warnstorf (Verh. bot. Ver.,

Berlin, xxxviii, 1896), the umbellules of the primary umbels bear hermaphrodite flowers at Ruppin; those of the secondary and tertiary ones marginal hermaphrodite and central male flowers.

VISITORS.—Herm. Müller gives the following list (' Fertilisation,' p. 283).—

A. Diptera. (*a*) *Bombyliidae*: 1. Anthrax maura *L.* (*b*) *Muscidae*: 2. Cyrtoneura curvipes *Macq.*, and C. simplex *Lw.* (both determined by Herr Winnertz); 3. Gymnosoma rotundata *L.*, freq.; 4. Lucilia cornicina *F.*; 5. Musca corvina *F.*; 6. Sepsis, freq. (*c*) *Stratiomyidae*: 7. Chrysomyia formosa *Scop.*, skg.; (*d*) *Syrphidae*: all nect-lkg.: 8. Cheilosia scutellata *Fall.*; 9. Eristalis arbustorum *L.*; 10. E. nemorum *L.*; 11. E. sepulcralis *L.*; 12. E. tenax *L.*; 13. Syritta pipiens *L.*; 14. Syrphus pyrastri *L.* (*e*) *Tipulidae*: 15. Tipula sp. **B. Hymenoptera:** (*a*) *Apidae*: 16. Andrena dorsata *K.* ♀, po-cltg.; 17. A. parvula *K.* ♀, do.; 18. Prosopis armillata *Nyl.* ♂ (Borgstette, Tecklenburg); 19. P. communis *Nyl.* ♀ and ♂ (Borgstette, Tecklenburg); 20. P. sinuata *Schenck* ♀ and ♂; 21. Sphecodes gibbus *L.* ♂ and ♀, freq. (*b*) *Chrysididae*: 22. Chrysis bidentata *L.* ♀; 23. C. ignita *L.* ♀; 24. Hedychrum lucidulum *F.* ♀ and ♂, not infrequent. (*c*) *Evaniidae*: 25. Foenus affectator *F.*; 26. F. jaculator *F.* (*d*) *Formicidae*: 27. Not infrequent. (*e*) *Ichneumonidae*: 28. Numerous species. (*f*) *Scoliidae*: 29. Tiphia femorata *F.* ♀. (*g*) *Sphegidae*: 30. Cemonus unicolor *F.* ♀; 31. Crabro denticrus *H.-Sch.*; 32. C. podagricus *H.-Sch.* ♀; 33. C. sexcinctus *F.* ♂; 34. C. vexillatus *Pz.* ♀; 35. C. wesmaeli *v. d. L.* ♂; 36. Mutilla melanocephala *F.*; 37. Oxybelus uniglumis *L.*, freq.; 38. Pompilus cinctellus *Spin.* ♀; 39. P. neglectus *Dahlb.* ♀; 40. Psen atratus *Pz.* ♀ and ♂; 41. Tachytes pectinipes *L.* ♀; 42. Trypoxylon clavicerum *Lep.* ♀. (*h*) *Tenthredinidae*: 43. Several species of Tenthredo. (*i*) *Vespidae*: 44. Eumenes pomiformis *F.* ♂; 45. Odynerus debilitatus *Sauss.*; 46. O parietum *L.*: 47. Polistes gallica *L.*

Sickmann (Osnabrück) saw the fossorial wasp Crabro lituratus *Pz.*, rare.

According to Marshall (in André, 'Spéc. des hym. d'Eur.,' IV, p. 563), the Braconid Agathis umbellatarum *Nees* is especially attracted by this species.

Loew gives the following for Silesia (' Beiträge,' pp. 28–9).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *F.*, nect-lkg. (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.*, nect-lkg. (*c*) *Telephoridae*: 3. Rhagonycha melanura *F.*, nect-lkg. (*d*) *Nitidulidae*: 4. Meligethes sp. (*e*) *Silphidae*: 5. Necrophorus vespillo *L.* **B. Diptera.** (*a*) *Muscidae*: all skg.: 6. Anthomyia sp.; 7. Gymnosoma rotundata *L.*; 8. Lucilia caesar *L.*; 9. Phasia analis *F.*; 10. P. crassipennis *F.* (*b*) *Mycetophilidae*: 11. Sciara thomae *L.* (*c*) *Stratiomyidae*: 12. Chrysomyia formosa *Scop.*, skg.; 13. Stratiomys chamaeleon *Deg.*, do. (*d*) *Syrphidae*: all skg.: 14. Eristalis nemorum *L.*; 15. Helophilus floreus *L.*; 16. Melithreptus scriptus *L.*; 17. Syritta pipiens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 18. Andrena gwynana *K.*, var. bicolor *F.* ♀, skg.; 19. A. lucens *Imh.* ♀, skg. and po-cltg.; 20. A. pilipes *F.* ♂, skg.; 21. A. propinqua *Schenck* ♀, do.; 22. A. tibialis *K.* ♂ (?); 23. Apis mellifica *L.* ☿, skg.; 24. Halictus sexnotatus *K.* ♀, do.; 25. Sphecodes gibbus *L.* ♂, do. (*b*) *Chrysididae*: 26. Chrysis viridula *L.* (*c*) *Ichneumonidae*: 27. Undetermined species. (*d*) *Sphegidae*: all skg.: 28. Cerceris arenaria *L.*, 29. Crabro albilabris *F.*; 30. C. subterraneus *F.*; 31. C. vexillatus *Pz.*; 32. Oxybelus lineatus *F.* ♀; 33. O. mucronatus *F.* ♂ and ♀; 34. O. pulchellus *Gorst.* ♂; 35. O. uniglumis *L.* ♂; 36. Pompilus viaticus *L.* (*e*) *Scoliidae*: 37. Tiphia femorata *F.* ♀, skg. (*f*) *Tenthredinidae*: 38. Hylotoma ciliaris *L.*, var. corrusca *Gadd.*; 39. Tenthredo sp. (*g*) *Vespidae*: all skg.: 40. Odynerus parietum *L.*; 41. Polistes gallica *L.*; 42. Vespa germanica *F.* ☿. **D. Lepidoptera.** *Rhopalocera*: both skg.: 43. Epinephele janira *L.*; 44. Polyommatus virgaureae *L.*

364. Pastinaca L.

1167. P. sativa L. (=Peucedanum sativum *Benth. et Hook. f.*).—According to Schulz ('Beiträge,' II, pp. 85, 93, 190), the yellow flowers of this species are distributed andromonoeciously, and the hermaphrodite ones are protandrous. The primary umbels either bear only hermaphrodite flowers, or may possess a central male one, or even several such. Secondary umbels often bear marginal hermaphrodite and central male flowers; sometimes hermaphrodite ones only. Umbels of higher order include numerous male flowers. Purely male umbels are rare. Warnstorf says that at Ruppin the umbellules of primary umbels are hermaphrodite; secondary ones bear marginal hermaphrodite and central male flowers; tertiary ones are almost exclusively male.

Hermann Müller states that the yellow flowers are not readily visited by beetles, and Kerner says that they are especially attractive to dung-flies.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list (Herm. Müller, 'Fertilisation,' p. 284, 'Weit. Beob.,' I, p. 306).—

A. Diptera. (*a*) *Bombyliidae*: 1. Anthrax flava *Mg.* (H. M.). (*b*) *Muscidae*: 2. Dexia rustica *F.* (H. M.); 3. Lucilia sylvarum *Mg.* (H. M.); 4. Onesia sepulcralis *Mg.* (H. M.); 5. Sarcophaga carnaria *L.* (H. M.). (*c*) *Syrphidae*: 6. Chrysotoxum bicinctum *L.* (H. M.); 7. Syritta pipiens *L.*, po-dvg. (H. M., Budd.). **B. Hymenoptera.** (*a*) *Ichneumonidae*: 8. Numerous species (H. M.). (*b*) *Scoliidae*: 9. Tiphia femorata *F.* (H. M.). (*c*) *Sphegidae*: 10. Crabro sexcinctus *F.* ♂ (H. M.); 11. Mutilla europaea *L.* ♀ (H. M.); 12. M. melanocephala *F.* ♂ (Budd.). (*d*) *Tenthredinidae*: 13. Several species of Tenthredo (H. M.). (*e*) *Vespidae*: 14. Odynerus parietum *L.* ♂ (H. M.); 15. Polistes biglumis *L.* (H. M.); 16. P. gallica *L.* (H. M.).

The following were recorded by the observers, and for the localities stated.—

Alfken (Bremen), a Muscid (Nemoraea erythrura *Mg.*), a bee (Andrena austriaca *Pz.* ♀), and a saw-fly (Allantus omissus *Först.*). Friese (Central Saalthal),—**Hymenoptera.** (*a*) *Ichneumonidae*: 1. Amblyteles fossorius (Müll.) *Wesm.*; 2. A. fuscipennis *Wesm.*; 3. A. sputator (F.) *Wesm.*; 4. Exenterus apiarius (Gr.) *Ths.*; 5. Exoechus gravipes *Gr.*; 6. Ichneumon similatorius (F.) *Ths.*; 7. Tryphon elongator *Gr.* (*b*) *Mutillidae*: 8. Mutilla rufipes *F.*, var. nigra *Rossi.* (*c*) *Sphegidae*: 9. Salius hyalinatus *F.*; 10. S. versicolor *Scop.* (*d*) *Vespidae*: Polistes gallica *L.* Schiner (Austria),—**Diptera.** (*a*) *Conopidae*: 1. Conops capitatus *Loew.* (*b*) *Muscidae*: 2. Alophora hemiptera *F.*; 3. Frontina laeta *Mg.*; 4. Germaria ruficeps *Fall.*; 5. Nemoraea radicum *F.*; 6. Phorocera punicata *Mg.* (*c*) *Syrphidae*: 7. Chrysotoxum bicinctum *L.*; 8. C. elegans *Loew*; 9. Eumerus sinuatus *Loew*; 10. Syrphus cinctellus *Zett.*; 11. S. cinctus *Fall.* F. F. Kohl (Tyrol), 2 ruby-wasps (Chrysis analis *Spin.*, and Hedychrum rutilans *Dahlb.*) and 3 true wasps (1. Odynerus parietum *L.*, var. renimacula *Lep.*; 2. O. parvulus *Lep.*; 3. O. rossi *Lep.*). Schletterer (Tyrol), the Scoliid Tiphia femorata *F.* Loew (Mecklenburg), Anthomyia sp.; (Brandenburg), the bee Halictus cylindricus *F.* ♂, skg.; (Steiermark), a Sphegid (Crabro sp.). Warnstorf (Brandenburg), bees, species not stated. MacLeod (Flanders), a hover-fly, 2 Muscids, and a short-tongued Neuropterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 275).

1168. P. opaca Bernh.—Schulz ('Beiträge,' II, p. 180) describes this species as andromonoecious, with protandrous hermaphrodite flowers.

365. Heracleum L.

1169. H. Sphondylium L.—The odorous flowers of this species are usually white and actinomorphous, but Kirchner says that they are sometimes irregular, and

greenish, yellowish, or reddish in colour. According to Ricca and Schulz, they are always hermaphrodite and markedly protandrous. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) states that in Brandenburg this common umbellifer is extremely variable as regards the colour and form of the petals. (*Cf.* Schr. natw. Ver., Weringerode, vii, 1892, pp. 64–6.) The umbellules of primary umbels bear hermaphrodite flowers; those of secondary ones marginal hermaphrodite and central male flowers; tertiary ones are nearly all male. Sometimes all the flowers of all the umbels are female by degeneration of the anthers, which are then bent back on the ovary, and contain vestigial pollen-grains only about 25 μ long and 12–13 μ broad, the ordinary fertile ones being about double the size. At Ruppin therefore the species is andromonoecious and gynodioecious (Warnstorf).

Visitors.—The gigantic inflorescences are visited by innumerable short-tongued insects.

Herm. Müller (H. M.), Buddeberg (Budd.), and Borgstette (Borg.) have observed the following (Herm. Müller, 'Fertilisation,' pp. 284–5, 'Weit. Beob.,' I, p. 306).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura maculicornis *Deg.*, freq. (H. M.); 2. L. testacea *L.* (Budd.); 3. Pachyta octomaculata *F.* (H. M., Budd.); 4. Stenocorus mordax *Deg.* (H. M.); 5. Strangalia armata *Hbst.* (Budd.); 6. S. attenuata *L.* (Budd.); 7. S. melanura *L.*, very freq., nect-lkg. (H. M.); 8. S. nigra *L.* (H. M.). (*b*) *Chrysomelidae*: 9. Cryptocephalus sericeus *L.* (H. M.). (*c*) *Cleridae*: 10. Trichodes apiarius *L.* (H. M.). (*d*) *Coccinellidae*: 11. Exochomus aurietus *Scriba* (H. M.). (*e*) *Dermestidae*: 12. Anthrenus pimpinellae *F.* (H. M.). (*f*) *Elateridae*: 13. Agriotes ustulatus *Schaller* (H. M.); 14. Corymbites holosericeus *Oliv.* (H. M.); 15. C. purpureus *Poda* (H. M.). (*g*) *Mordellidae*: 16. Mordella fasciata *F.*, nect-lkg. (H. M.). (*h*) *Nitidulidae*: 17. Meligethes, freq. (H. M.); 18. Thalycra fervida *Gyll.* (H. M.). (*i*) *Oedemeridae*: 19. Oedemera virescens *L.* (H. M.). (*k*) *Scarabaeidae*: 20. Cetonia aurata *L.*, very freq. (H. M.); 21. Hoplia philanthus *Sulz.*, do. (H. M.); 22. Oxythyrea funesta *Poda*, freq. (H. M.); 23. O. hirta *Poda* (Budd.); 24. Trichius fasciatus *L.* freq. (H. M.). (*l*) *Telephoridae*: 25. Telephorus fuscus *L.* (H. M.); 26. T. lividus *L.* (H. M.); 27. T. melanurus *F.*, very numerous (H. M.). **B. Diptera.** (*a*) *Asilidae*: 28. Dioctria reinhardi *Wied.*, freq. (H. M.). (*b*) *Bibionidae*: 29. Dilophus vulgaris *Mg.*, ♀ freq., ♂ infreq. (H. M.). (*c*) *Bombyliidae*: 30. Anthrax flava *Mg.* (H. M., Borg.); 31. A. hottentotta *L.* (Budd.). (*d*) *Conopidae*: 32. Myopa occulta *Mg.* (H. M.); 33. Zodion cinereum *F.*, nect-lkg. (H. M.). (*e*) *Empidae*: 34. Empis livida *L.* (H. M.). (*f*) *Muscidae*: 35. Calliphora erythrocephala *Mg.* (H. M.); 36. C. vomitoria *L.* (H. M.); 37. Cynomyia mortuorum *L.*, nect-lkg. (Budd.); 38. Echinomyia fera *L.* (H. M.); 39. E. grossa *L.* (H. M.); 40. E. lurida *F.* (Budd.); 41. E. magnicornis *Zett.* (H. M., Budd.); 42. Exorista vulgaris *Fall.* (H. M.); 43. Graphomyia maculata *Scop.* (H. M.); 44. Lucilia caesar *L.* (H. M.); 45. L. cornicina *F.* (H. M.); 46. L. sericata *Mg.* (H. M.); 47. L. sylvarum *Mg.* (H. M.); 48. Mesembrina meridiana *L.* (H. M.); 49. Musca corvina *F.* (H. M.); 50. Nemoraea sp. (H. M.); 51. Onesia floralis *Rob.-Desv.* (H. M.); 52. O. sepulcralis *Mg.* (H. M.); 53. Phasia analis *F.* (H. M.); 54. Pollenia vespillo *F.* (H. M.); 55. Pyrellia aenea *Zett.* (H. M.); 56. Sarcophaga carnaria *L.*, freq. (H. M.); 57. S. haemarrhoa *Mg.* (H. M.); 58. Scatophaga merdaria *F.*, freq. (H. M.); 59. Sepsis cynipsea *L.*, do. (H. M.); 60. Tachina erucarum *Rond.* (H. M.). (*g*) *Mycetophilidae*: 61. Platyura sp. (H. M.). (*h*) *Syrphidae*: 62. Ascia lanceolata *Mg.* (H. M.); 63. A. podagrica *F.* (H. M.); 64. Cheilosia scutellata *Fall.* (H. M.); 65. C. oestracea *L.*, freq. (H. M.); 66. Chrysogaster viduata *L.* (H. M.); 67. Chrysotoxum bicinctum *L.*, rare (H. M.); 68. C. festivum *L.* (Borg.); 69. Eristalis aeneus *Scop.* (H. M.); 70. E. arbustorum *L.* (H. M.); 71. E. horticola *Mg.* nect-lkg. (H. M.); 72. E. nemorum *L.* (H. M.);

73. E. pertinax *Scop.* (H. M.); 74. E. sepulcralis *L.* (H. M.); 75. E. tenax *L.* (H. M.); 76. Helophilus floreus *L.*, freq. (H. M.); 77. Melanostoma mellina *L.* (H. M.); 78. Melithreptus menthastri *L.* (H. M.); 79. Pipizella annulata *Macq.* (H. M.); 80. P. virens *F.* (H. M.); 81. Syritta pipiens *L.* (H. M.); 82. Syrphus balteatus *Deg.* (H. M.); 83. S. glaucius *L.* (H. M.); 84. S. pyrastri *L.* (H. M.); 85. S. ribesii *L.* (H. M.); 86. Volucella pellucens *L.*, nect-lkg. (Budd.); 87. Xylota florum *F.*, nect-lkg. (H. M.). (*i*) *Tabanidae*: 88. Tabanus micans *Mg.* (Budd.); 89. T. rusticus *L.* (H. M.). (*k*) *Tipulidae*: 90. Pachyrhina histrio *F.* (H. M.). **C. Hemiptera.** 91. Several bugs (H. M.). **D. Hymenoptera.** (*a*) *Apidae*: 92. Andrena argentata *Sm.* ♀, po-cltg. (H. M.); 93. A. coitana *K.* ♀, nect-lkg. (H. M.); 94. A. fucata *Sm.* ♀, skg. and po-cltg. (H. M.); 95. A. nana *K.* ♀, skg. (H. M.); 96. A. nitida *K.* ♀, one (Budd.); 97. A. rosae *Pz.* ♀, freq. (H. M.); 98. A. tibialis *K.* ♀, one (Budd.); 99. Apis mellifica ☿, skg. and po-cltg. (H. M.); 100. Bombus terrester *L.* ♀, po-cltg. (H. M.); 101. Halictus cylindricus *F.* ♀, do. (H. M.); 102. H. flavipes *F.* ♀ (H. M.); 103. H. leucopus *K.* ♂ (H. M.); 104. H. lugubris *K.* ♀, in large numbers (H. M.); 105. H. tetrazonius *Klg.* ♀ (Budd.); 106. Megachile centuncularis *L.* ♀, po-cltg. (H. M.); 107. Nomada ferruginata *K.* ♀, skg. (H. M.); 108. Prosopis armillata *Nyl.* ♀ (H. M.); 109. Sphecodes gibbus *L.* ♂, skg. (H. M.). (*b*) *Evaniidae*: 110. Foenus sp., nect-lkg. (Budd.). (*c*) *Ichneumonidae*: 111. Numerous species (H. M.). (*d*) *Sphegidae*: 112. Cerceris quadrifasciata *Pz.* (H. M.); 113. Ceropales maculatus *F.*, not infrequent (H. M.); 114. Crabro cribrarius *L.* ♀ and ♂ (H. M.); 115. C. lapidarius *Pz.* ♀ and ♂, in great numbers (H. M.); 116. C. vagus *L.* ♀ and ♂ (H. M.); 117. Dinetus pictus *F.* ♀ and ♂, in great numbers (H. M.); 118. Gorytes campestris *Müll.* ♀ and ♂ (H. M.); 119. G. quadrifasciatus *F.* ♂ (H. M.); 120. G. quinquecinctus *F.* ♀ and ♂, freq. (H. M.); 121. Mimesa bicolor *Jur.* (H. M.); 122. M. unicolor *v. d. L.* (H. M.). (*e*) *Mutillidae*: 123. Myrmosa melanocephala *F.* ♂ (H. M.). (*f*) *Sphegidae*: 124. Nysson maculatus *F.* ♀ (H. M.); 125. N. spinosus *Forst.*, nect-lkg. (H. M.); 126. Oxybelus uniglumis *L.*, freq. (H. M.); 127. Philanthus triangulum *F.* ♀ (H. M.). (*g*) *Pompilidae*: 128. Pompilus neglectus *Dahlb.* (H. M.); 129. P. pictinipes *v. d. L.* ♂ (H. M.); 130. P. viaticus *L.* ♂ (H. M.); 131. Salius exaltatus *F.* (H. M.). (*h*) *Scoliidae*: 132. Tiphia femorata *F.*, numerous (H. M.). (*i*) *Tenthredinidae*: 133. Abia sericea *L.*, not infrequent, nect-lkg. (H. M.); 134. Allantus albicornis *F.* ♀ (H. M.); 135. A. bicinctus *L.* (Budd.); 136. A. marginellus *Klg.* (Budd.); 137. A. nothus *Klg.*, not infrequent (H. M.); 138. A. tricinctus *F.* (H. M.); 139. Athalia annulata *F.* (H. M.); 140. A. rosae *L.* (H. M.); 141. Hylotoma caerulescens *F.* (H. M.); 142. H. enodis *L.* (H. M.); 143. H. femoralis *Klg.* (H. M.); 144. H. rosarum *Klg.* (H. M.); 145. H. ustulata *L.* (H. M.); 146. H. vulgaris *Klg.* (H. M.); 147. Macrophya rufipes *L.* (H. M.); 148. M. rustica *L.* (Budd.); 149. Tenthredo bifasciata *Klg.* (Allantus rossii *Pz.*) freq. (H. M.); 150. T. sp. (H. M.). (*k*) *Vespidae*: 151. Odynerus bifasciatus *L.*, ♀ and ♂ (H. M.); 152. O. gazella *Pz.* ♂ (H. M.); 153. O. parietum *L.*, numerous (H. M.); 154. O. sinuatus *F.* (H. M.); 155. O. trifasciatus *F.* ♀ (H. M.); 156. Vespa germanica *F.* ♂ and ☿, freq. (H. M.); 157. V. rufa *L.* ♀ (H. M.); 158. V. sylvestris *Scop.* ♂ (H. M.); 159. V. vulgaris *L.* ☿ (H. M.). **E. Lepidoptera.** (*a*) *Rhopalocera*: 160. Thecla betulae *L.*, skg. (H. M.). (*b*) *Tineidae*: 161. Hyponomeuta sp. (H. M.); 162. Nemotois scabiosellus *Scop.* ♀, skg. (Budd.). **F. Neuroptera.** *Planipennia*: 163. Panorpa communis *L.*, nect-lkg., in great numbers (H. M.).

Alfken records the following for Bremen.—

A. Coleoptera. 1. Aromia moschata *L.*; 2. Cetonia aurata *L.* **B. Diptera.** (*a*) *Muscidae*: 3. Exorista vulgaris *Fall.*; 4. Musca domestica *L.*; 5. Oliviera lateralis *F.*; 6. Pollenia vespillo *F.*; 7. Trypeta wintheoni *Mg.* (*b*) *Syrphidae*: 8. Arctophila mussitans *F.*; 9. Ascia lanceolata *Mg.*; 10. A. podagrica *F.*; 11. Bacha elongata *F.*; 12. Chrysotoxum bicinctum *L.*; 13. C. festivum *L.*; 14. Helophilus floreus *L.*; 15. Merodon albifrons *Mg.*; 16. Syrphus glaucius *L.*; 17. S. pyrastri *L.*; 18. Volucella bombylans *L.*; 19. Xylota segnis *L.* **C. Hymeno-**

ptera. (*a*) *Apidae*: 20. Andrena austriaca *Pz.* ♀; 21. A. flavipes *Pz.* ♀, 2nd gen.; 22. A. parvula *K.* ♀ and ♂; 23. Eriades nigricornis *Nyl.* ♀; 24. Halictus calceatus *Scop.* ♂; 25. Prosopis communis *Nyl.* ♀; 26. P. pictipes *Nyl.* ♂; 27. P. punctatissima *Sm.* ♂. (*b*) *Ichneumonidae*: 28. Exyston cinctulus *Gr.*; 29. Glypta incisa *Gr.*; 30. Ichneumon gradarius *Wesm.*; 31. Stylocryptus vagabundus *F.* (*c*) *Sphegidae*: 32. Crabro brevis *v. d. L.* ♀ and ♂; 33. C. subterraneus *F.* ♀ and ♂; 34. C. vagabundus *Pz.* ♀. (*d*) *Tenthredinidae*: 35. Allantus arcuatus *Forst.*; 36. A. omissus *Forst.*; 37. A. vespa *Retz.*; 38. Athalia glabricollis *Ths.*; 39. A. spinarum *F.*; 40. Entodecta pumila *Klg.*; 41. Selandria cinereipes *Klg.* (*e*) *Vespidae*: 42. Odynerus clavipennis *Ths.* ♀; 43. O. oviventris *Wesm.* ♀; 44. O. parietum *L.* ♀ and ♂.

Loew gives the following for Silesia ('Beiträge,' p. 29).—

A. Coleoptera. *Telephoridae*: 1. Anthocomus fasciatus *L.*, nect-lkg.; 2. Axinotarsus pulicarius *F.*, do. **B. Diptera.** (*a*) *Empidae*: 3. Rhamphomyia umbripennis *Mg.*, skg. (*b*) *Muscidae*: 4. Metopia leucocephala *Rossi*, skg.; 5. Olivieria lateralis *F.*; 6. Tachina agilis *Mg.* (*c*) *Mycetophilidae*: 7. Sciara thomae *L.* (*d*) *Stratiomyidae*: 8. Stratiomys chamaeleon *Deg.*, skg.; 9. S. equestris *Mg.*, do.; 10. S. furcata *F.*, do. (*e*) *Syrphidae*: 11. Cheilosia mutabilis *Fall.*; 12. Helophilus floreus *L.*, skg; 13. Syrphus balteatus *Deg.*, do.; 14. S. seleniticus *Mg.*, do.; 15. S. umbellatarum *F.*, do. **C. Hymenoptera.** (*a*) *Chrysididae*: 16. Cleptes semiauratus *L.* (*b*) *Sphegidae*: 17. Cerceris labiata *F.* ♂, skg.; 18. C. nasuta *Ltr.* ♂, do.; 19. Crabro patellatus *Pz.*, do.; 20. C. vexillatus *Pz.* ♂, do.; 21. Philanthus triangulum *F.* ♂, do. (*c*) *Tenthredinidae*: 22. Dolerus pratensis *L.*; 23. Hylotoma enodis *L.*, skg.; 24. H. ustulata *L.*, do. (*d*) *Vespidae*: 25. Polistes gallica *L.*, skg.

Loew observed the following in Brandenburg ('Beiträge,' p. 36).—

A. Coleoptera. *Cerambycidae*: 1. Leptura testacea *L.* ♀ and ♂. **B. Diptera.** (*a*) *Muscidae*: 2. Gymnosoma rotundata *L.*; 3. Phasia crassipennis *F.* **C. Hymenoptera.** (*a*) *Apidae*: 4. Halictus leucozonius *Schr.* ♀, skg. (*b*) *Scoliidae*: 5. Tiphia femorata *F.* ♀ and ♂. (*c*) *Sphegidae*: 6. Crabro albilabris *F.* ♀, do.; 7. C. subterraneus *F.* ♀, skg.; 8. Hoplisius quadrifasciatus *F.*, do.; 9. Mellinus arvensis *L.* ♀; 19. Pompilus quadripunctatus *F.* (*d*) *Tenthredinidae*: 11. Allantus scrophulariae *L.* (*e*) *Vespidae*: 12. Vespa germanica *F.* ♀, skg.

Loew records the following for the Riesengebirge (R.), Silesia (S.), and Glatz (G.) ('Beiträge,' p. 48).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.* (S.); 2. C. mysticus *L.* (S.); 3. Leptura testacea *L.* ♀ and ♂ (S.); 4. Strangalia annularis *F.* (R.); 5. S. bifasciata *Müll.* ♀ and ♂ (R.). (*b*) *Scarabaeidae*: 6. Trichius fasciatus *L.* (R.). (*c*) *Telephoridae*: 7. Cantharis alpina *Payk.* (S.). **B. Diptera.** (*a*) *Bibionidae*: 8. Bibio pomonae *F.* (R.). (*b*) *Conopidae*: 9. Conops quadrifasciatus *Deg.* (G.). (*c*) *Muscidae*: 10. Gymnosoma rotundata *L.* (G.); 11. Leucostoma analis *Mg.* (G.). (*d*) *Pipunculidae*: 12. Pipunculus ruralis *Mg.* (G.). (*e*) *Syrphidae*: 13. Cheilosia oestracea *L.* (S.); 14. Chrysotoxum octomaculatum *Curt.* (S.); 15. Syrphus glaucius *L.* (S.). **C. Hymenoptera.** (*a*) *Apidae*: 16. Halictus albipes *F.* ♂, skg. (G.); 17. H. morio *F.* ♀, do. (G.). (*b*) *Chrysididae*: 18. Chrysis ignita *L.* (G.). (*c*) *Sphegidae*: 19. Crabro cribrarius *L.* ♀ and ♂ (S.); 20. Mellinus arvensis *L.* (G.); 21. M. sabulosus *F.* (S.).

Sickmann gives the following list for Osnabrück.—

Hymenoptera. (*a*) *Sphegidae*: 1. Ammophila sabulosa *L.*, fairly freq.; 2. Calicurgus fasciatellus *Spin.*, not freq.; 3. Crabro alatus *Pz.*, do.; 4. C. cetratus *Shuck.*, do.; 5. C. chrysostomus *Lep.*, very common; 6. C. cribrarius *L.*, do.; 7. C. dives *H.-Sch.*, rare; 8. C. exiguus *v. d. L.*, fairly freq.; 9. C. gonager *Lep.*, very rare; 10. C. guttatus *v. d. L.* ♀; 11. C. larvatus *Wesm.* ♀; 12. C. lituratus *Pz.*, rare; 13. C. podagricus *v. d. L.*, freq.; 14. C. sexcinctus *F.*, very common;

15. C. spinicollis *H-Sch.*, freq.; 16. C. subterraneus *F.*, fairly freq.; 17. C. varius *Lep.*, freq.; 18. Dahlbomia atra *F.*; 19. Gorytes laticinctus *Shuck.*, infrequent; 20. C. mystaceus *L.*, freq.; 21. G. quadrifasciatus *F.*, do.; 22. Mellinus sabulosus *F.*, do.; 23. Mimesa bicolor *Jur.*; 24. M. dahlbomi *Wesm.*, rare; 25. M. equestris *F.*, very common; 26. Nysson maculatus *F.*, fairly freq.; 27. Oxybelus uniglumis *L.*, very common; 28. Pemphredon unicolor *F.*, freq.; 29. Pompilus abnormis *Dahlb.*, rare; 30. P. nigerrimus *Scop.*, freq.; 31. P. trivialis *Dahlb.*; 32. Psen atratus *Pz.*, very common; 33. Pseudagenia carbonaria *Scop.*, do.; 34. Salius exaltatus *F.*, do.; 35. S. notatus *Lep.*, freq.; 36. S. obtusiventris *Schjödte*, very rare; 37. Trypoxylon attenuatus *Sm.*, rare. (*b*) *Mutillidae*: 38. Myrmosa melanocephala *F.* ♂.

Friese observed the following.—

In Baden, 2 bees (Andrena austriaca *Pz.* ♀, and Halictus minutus *Schenck* (=H. rugulosus *Schenck*) ♀). In Thuringia.—**Hymenoptera.** (*a*) *Apidae*: 1. Andrena austriaca *Pz.*; 2. A. coitana *K.* (*b*) *Ichneumonidae*: 3. Amblyteles (Ctenichneumon) funereus *Fourcr.*; 4. A. (Protichneumon) fucipennis *Wesm.*; 5. Metopius micratorius *Gr.* (*c*) *Mutillidae*: 6. Mutilla rufipes *F.*, var. nigra *Rossi.* (*d*) *Sphegidae*: 7. Crabro alatus *Pz.*; 8. C. cribrarius *L.*; 9. C. lituratus *Pz.*; 10. Oxybelus nigripes *Oliv.*; 11. Pemphredon lugens *Dahlb.*; 12. Pompilus quadripunctatus *F.* (*e*) *Tenthredinidae*: 13. Allantus marginellus *F.*; 14. A. vespa *Retz.* (*f*) *Vespidae*: 15. Discoelius zonalis *Pz.*; 16. Odynerus crassicornis *Pz.*; 17. O. sinuatus *F.*; 18. Vespa austriaca *Pz.*

Schenck gives the following for Nassau.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena austriaca *Pz.*; 2. A. nana *K.*; 3. Halictus interruptus *Pz.*; 4. Prosopis trimaculata *Schenck.* (*b*) *Mutillidae*: 5. Myrmosa melanocephala *F.* ♀ and ♂. (*c*) *Scoliidae*: 6. Tiphia femorata *F.*; 7. T. minuta *v. d. L.* (*d*) *Sphegidae*: 8. Ceropales maculatus *F.*; 9. C. variegatus *F.*; 10. Dahlbomia atra *Pz.*; 11. Gorytes levis *Ltr.*; 12. G. mystaceus *L.*; 13. G. quadrifasciatus *F.*; 14. G. quinquecinctus *F.*; 15. Pompilus anceps *Sm.*; 16. P. trivialis *Dahlb.*; 17. Pompilus unicolor *Spin.*; 18. Psen atratus *Pz.*; 19. Tachysphex pectinipes *L.*

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 11 beetles, 5 flies, and 5 Hymenoptera ('Alpenblumen,' pp. 121–2). Schmiedeknecht (Thuringia),—4 bees—1. Andrena austriaca *Pz.*; 2. A. dubitata *Schenck*, 2nd gen.; 3. A. fulvicrus *K.* (=A. flavipes *Pz.*), do.; 4. Nomada obtusifrons *Nyl.* Krieger (Leipzig), 2 bees (Andrena austriaca *Pz.*, and A. denticulata *K.*), and 2 Sphegids (Mellinus sabulosus *F.* ♀, and Mimesa atra *F.*). Rössler (Wiesbaden) the moth Grapholitha aurana *F.*, group aurantiana *Kollar.* Schiner (Austria), 2 Muscids—1. Frontina laeta *Mg.*; 2. Homalomyia pretiosa *Schin.* Von Fricken (Westphalia and Eastern Prussia), the Scarabaeid Hoplia philanthus *Sulz.*, and the Cerambycid Acmaeops collaris *L.* von Dalla Torre (Tyrol), the ruby-wasp Chrysis austriaca *F.*, the true wasp Odynerus minutus *F.*, and 3 bees—1. Eriades campanularum *K.* ♂; 2. Halictus morio *F.*; 3. Osmia leucomelaena *K.* ♂. Schletterer (Tyrol), 2 bees—1. Halictus morio *F.*; 2. Nomada succincta *Pz.*: (Pola) the Scoliid Tiphia femorata *F.* Kohl (Tyrol), 2 true wasps—1. Odynerus spiricornis *Spin.*; 2. Eumenes arbustorum *Pz.*, var. dimidiata *Brull.*; the ruby-wasp Ellampus caeruleus *Dahlb.*; and 2 fossorial wasps—1. Crabro cribrarius *L.*; 2. C. scutellatus *Schev.* Handlirsch, 3 fossorial wasps—1. Gorytes bilunulatus *Costa* (on the authority of Schmiedeknecht); 2. G. quadrifasciatus *F.*; 3. G. quinquecinctus *F.* Redtenbacher (Vienna), the Cerambycid Callimus cyaneus *F.* Knuth (Helgoland).—**A. Diptera.** *Muscidae*: 1. Coelopa frigida *Fall.*; 2. C. pilipes *Hal.*; 3. Lucilia caesar *L.*; 4. Olivieria lateralis *F.*; 5. Scatella sp.; 6. Scatophaga stercoraria *L.*; 7. Medium-sized and minute sp. **B. Hymenoptera.** *Vespidae*: 8. One of the wasps, which escaped. MacLeod (Flanders), 3 short-tongued bees, a saw-fly, a true wasp, an

Ichneumonid, 6 hover-flies, 4 Muscids, a Lepidopterid, and 2 beetles (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 275–7, 380). Heinsius (Holland), 2 Muscids—1. Lucilia cornicina *F.*; 2. Scatophaga stercoraria *L.* ♀ and ♂; and the hover-fly Eristalis tenax *L.* ♀ (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, p. 59). Scott-Elliot (Dumfriesshire), Apis, a humble-bee, a wasp, 4 Muscids, and 4 hover-flies ('Flora of Dumfriesshire,' p. 80).

Loew observed the following in Switzerland ('Beiträge,' p. 56).—

A. Coleoptera. *Cerambycidae*: 1. Leptura maculicornis *Deg.*; 2. Pachyta lamed *L.*; 3. P. quadrimaculata *L.*; 4. P. virginea *L.*; 5. Strangalia armata *Hbst.* **B. Diptera.** (*a*) *Muscidae*: 6. Echinomyia fera *L.*; 7. Hydrotaea dentipes *F.* ♂; 8. Mesembrina meridiana *L.*; 9. M. mystacea *L.* (*b*) *Syrphidae*: 10. Eristalis rupium *F.*; 11. Melithreptus pictus *Mg.*; 12. Syritta pipiens *L.* **C. Hymenoptera.** *Sphegidae*: 13. Gorytes sp.; 14. Myrmosa melanocephala *F.* ♂.

H. de Vries noticed the following in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. Deel, 1875).—

Hymenoptera. (*a*) *Apidae*: 1. Apis mellifica *L.* ☿; 2. Bombus agrorum *F.* ☿; 3. B. subterraneus *L.* ☿; 4. B. terrester *L.* ☿ and ♂; 5. Halictus cylindricus *F.* ♂. (*b*) *Sphegidae*: 6. Crabro cribrarius *L.* ♀. (*c*) *Tenthredinidae*: 7. Allantus tricinctus *F.* (*d*) *Vespidae*: 8. Vespa germanica *F.* ☿.

1170. **H. pyrenaicum** Lam. (=H. montanum Schleich.).—The flowers of this species are white.

Visitors.—MacLeod (Pyrenees) observed 6 short-tongued Hymenoptera, 4 beetles, and 26 Diptera (8 Syrphids and 16 Muscids).

1171. **H. sibiricum** L.—Lindman says that the flowers of this species possess a strong urinous odour.

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Cistelidae*: 1. Cistela sulphurea *L.* (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.*, dvg. the flowers; 3. Phyllopertha horticola *L.*, do. **B. Diptera.** *Syrphidae*: 4. Eristalis arbustorum *L.*, skg.; 5. E. nemorum *L.*, do. **C. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.* ♀, skg. and po-cltg.

Lindman saw numerous Diptera and Hymenoptera on the Dovrefjeld.

1172. **H. dissectum** Ledeb. (=H. lanatum *Michx.*).—

Visitors.—Loew saw the bee Andrena schrankella *Nyl.* ♀, skg. and po-dvg., in the Berlin Botanic Garden.

1173. **H. pubescens** Bieb.—

Visitors.—Loew saw the following in the Berlin Botanic Garden.—

A. Coleoptera. *Scarabaeidae*: 1. Cetonia aurata *L.*, devouring the flowers. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg. and po-cltg.; also (on the var. *Wilhelmsii* Fisch. et Lall.), the Muscid, 3. Pollenia rudis *F.*

366. Tordylium Tourn.

1174. **T. maximum** L.—Schulz ('Beiträge,' II, p. 190) describes this species as andromonoecious, with protandrous hermaphrodite flowers.

1175. **T. apulum** L.—

Visitors.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena carbonaria *L.*; 2. A. parvula *K.*; 3. A. taraxaci *Gir.*, infreq.; 4. Halictus calceatus *Scop.*; 5. H. levigatus *K.* ♀; 6. H. minutus *K.*; 7. H. moris *F.*; 8. H. quadrinotatus *K.*; 9. H. variipes *Mor.* (*b*) *Braconidae*: 10. Bracon urinator *F.* (*c*) *Chrysididae*: 11. Chrysis angustifrons *Ab.*; 12. C. inaequalis *Dahlb.*; 13. Ellampus auratus *L.*; 14. Hedychrum longicolle *Ab.* (*d*) *Evaniidae*: 15. Gasteruption granulithorax *Tourn.*; 16. G. terrestre *Tourn.* (*e*) *Ichneumonidae*: 17. Amblyteles armatorius *Forst.* (=A. fasciatorius *F.*); 18. Angitia armillata *Gr.*; 19. Anilasta notata *Gr.*; 20. Cryptius hellenicus *Schmiedekn.*; 21. C. viduatorius *F.*; 22. Hoplocryptus heliophilus *Tschek.*; 23. Ichneumon bilunulatus *Gr.*; 24. I. finitimus *Tischb.*; 25. I. scanthorius *Forst.*; 26. Omorga mutabilis *Hgr.*; 27. Pimpla instigator *F.*; 28. P. roberator *F.*; 29. Trychosis plebeia *Tschek.*, with the vars. nigricornis *Krchb.* and nigritarsis *Krchb.* (*f*) *Pompilidae*: 30. Pompilus minutus *Dahlb.* (=P. cellularis *Dahlb.*); 31. P. sexmaculatus *Spin.*; 32. P. viaticus *L.*; 33. Salius fuscus *F.*; 34. S. parvulus *Dahlb.* (*g*) *Scoliidae*: 35. Tiphia minuta *v.d.L.*; 36 T. morio *F.*; 37. T. femorata *F.* (*h*) *Sphegidae*: 38. Cerceris quadrifasciata *Pz.*; 39. Crabro clypeatus *L.*; 40. C. meridionalis *Costa*; 41. Diodontus minutus *F.* ♂; 42. Gorytes pleuripunctatus *Costa.* (*i*) *Tenthredinidae*: 43. Allantus fasciatus *Scop.*; 44. A. viduus *Rossi*; 45. Amasis laeta *F.*; 46. Arge cyaneocrocea *Först.*; 47. A. melanochroa *Gmel.*; 48. Athalia annulata *F.*; 49. A. glabricollis *Ths.*, freq.; 50. A. spinarum *F.*; 51. A. rosae *L.*, var. cordata *Lep.*; 52. Macrophya rustica *L.* (*k*) *Vespidae*: 53. Polistes gallica *L.*

367. Siler Crantz.

1176. **S. trilobum** Crantz (=Laserpitium aquilegiaefolium *Jacq.*).—Schulz ('Beiträge,' II, pp. 85–6, 190) describes this species as andromonoecious, with protandrous hermaphrodite flowers. The male flowers are numerous, and situated in the middle of the umbellules. According to Kerner, the direction of the styles and the position of the stigmas remain unchanged, but the slender filaments elongate and curve in such a way that the pollen is applied to the stigmas of neighbouring flowers ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 324).

Visitors.—Loew observed the following in Steiermark ('Beiträge,' p. 48).—

A. Coleoptera. 1. Anoncodes rufiventris *Scop.*; 2. Chrysanthia viridissima *L.*; 3. Oxythyrea stictica *L.*; 4. Strangalia armata *Hbst.* **B. Diptera.** *Muscidae*: 5. Clytia pellucens *Fall.*; 6. Echinomyia ferox *Pz.* **C. Hemiptera.** 7. Nabis sp.; 8. Graphosoma lineatum *L.*; 9. Undetermined sp. And in the Berlin Botanic Garden—**A. Diptera.** *Syrphidae*: 1. Eristalis nemorum *L.*, skg.; 2. Syritta pipiens *L.*, do.; 3. Syrphus ribesii *L.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Andrena tibialis *K.* ♀, skg. and po-cltg.; 5. Apis mellifica *L.* ☿, do.; 6. Prosopis communis *Nyl.* ♀, skg. (*b*) *Vespidae*: 7. Odynerus parietum *L.*

368. Laserpitium L.

1177. **L. latifolium** L.—The flowers of this species are white or rarely reddish in colour. Schulz ('Beiträge,' II, pp. 90, 94, 190) describes them as andromonoeciously distributed, those which are hermaphrodite being markedly protandrous. The primary umbels usually bear hermaphrodite flowers only, those of higher order chiefly male ones. According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 296), there are short-stalked pseudo-hermaphrodite male flowers in all the umbellules, surrounded by long-stalked, truly hermaphrodite ones.

1178. **L. prutenicum** L.—Schulz states that the yellowish-white flowers of this species are all hermaphrodite, and markedly protandrous ('Beiträge,' II, p. 190).

1179. **L. hirsutum** (=L. Panax *Gouan*).—Hermann Müller describes the white flowers of this species as protandrous ('Alpenblumen,' p. 122).

Visitors.—Herm. Müller observed a beetle, 23 Diptera (including 17 Muscids), 7 Hymenoptera, and 3 Lepidoptera, in the Alps.

369. Daucus L.

1180. **D. Carota** L.—Schulz ('Beiträge,' II, pp. 86–9, 91, 93, 190) describes this species as andromonoecious, with white flowers, of which the hermaphrodite ones are markedly protandrous. For Holland monoecism has also been recorded, and in Central Germany purely female flowers have been observed. The marginal blossoms, as in many Umbelliferae, are much bigger than the others, their outer petals being specially enlarged. Schulz was able to distinguish two varieties in the Tyrol and Central Germany. The commoner bears white hermaphrodite and male flowers in the same umbellule; the latter being central and more numerous in the umbels of higher order. The second rarer variety often bears flowers tinged with green or red; their umbellules either bear female flowers only, or these and neuter ones. In many cases the anthers contain normal pollen-grains, often mixed with smaller irregular ones. They rarely dehisce, and remain in the position which they occupied in the bud. The terminal flowers are either female or neuter.

According to Warnstorf, the umbellules of primary umbels bear hermaphrodite flowers at Ruppin; secondary ones marginal hermaphrodite and, as a rule, a few central male flowers; tertiary umbels are almost exclusively male. The terminal flower in the umbellules of secondary umbels is commonly hermaphrodite; rarely all the umbels are female by degeneration of the anthers.

A very remarkable feature is the occurrence of an enlarged actinomorphous central flower of a purple-red colour. In rare cases several may be present, even as many as 5 to 10. This flower is sometimes wanting, e.g., according to Buchenau ('Flora d. ostfr. Ins.,' p. 143), in some parts of the East Frisian Islands. It is not often met with in the North Frisian Islands (Knuth, 'Flora d. nordfr. Ins.,' p. 67). Schulz states that a terminal umbellule occurs in at most 3–5 % of all the umbels, and only a small fraction of this number possess one or more of the purple-red flowers (Bot. Centralbl., Cassel, li, 1892, p. 12). Kronfeld describes these flowers as cleistogamous and fertile; he regards them as due to inherited gall-formation. (*Cf.* Justs bot. Jahresber., Leipzig, xx, (1892) 1894, p. 491.)

The umbellules of plants observed by Beijerinck ('Gynodioeciae bei Daucus Carota') at Wageningen in Holland possessed central male and marginal female flowers, often with a single terminal hermaphrodite one as well. In plants examined by Staes (Bot. Jaarb. Dodonaea, Ghent, i, 1889, p. 124) in Belgium (Ghent and Blankenberg) the marginal flowers were hermaphrodite instead of female. The form with reddish blossoms considered by Beijerinck to be physiologically female not infrequently bears hermaphrodite flowers, and can therefore be fertilized independently of the white-flowered variety. Schulz has not observed the forms described by Beijerinck, either in Central Germany or in the Tyrol.

The two different forms of umbels of this species are described as follows by Beijerinck (op. cit.) and Staes (op. cit.), for Holland (Wageningen) and Belgium (Ghent and the Blankenberg dunes) respectively.—

1. Form with white flowers.

At Wageningen, according to Beijerinck, the marginal flowers of all the umbellules are either devoid of stamens, or if these are present they drop off before their anthers dehisce.

These flowers are therefore always female.

At Ghent and Blankenburg, according to Staes, the stamens may be vestigial, but are usually fertile.

These flowers may therefore be female, but are often hermaphrodite.

2. Form with red or greenish-red flowers.

At Wageningen the stamens are often more or less metamorphosed into petals; the anthers never dehisce.

The whole umbel is female.

At Wageningen this form can only reproduce with the aid of the white-flowered one.

At Ghent and Blankenberg the stamens, when not degenerate, often possess anthers that dehisce.

The umbel may be female (owing to degenerate stamens, or anthers which do not dehisce); it is often, however, hermaphrodite.

At Ghent and Blankenberg the two forms can reproduce independently of each other..

Deichmann (Bot. Centralbl., Cassel, xlix, 1892, p. 271) calls attention to the fact that in Denmark, owing to frequent crossing of the cultivated variety with the wild form the former displays an unwelcome reversion.

VISITORS.—I observed the following at Glücksburg ('Bloemenbiol. Bijdragen').—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella septempunctata *L.* (*b*) *Telephoridae*: 2. Cantharis fusca *L.* **B. Diptera.** (*a*) *Muscidae*: 3. Lucilia caesar *L.* (*b*) *Syrphidae*: 4. Syrphus balteatus *Deg.* **C. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿; 6. Bombus terrester *L.* ♀. All skg., or po-cltg., or po-dvg.: the last running over the inflorescences with great rapidity.

In Schleswig-Holstein I saw 4 hover-flies, a Muscid, a humble-bee, and a fossorial wasp ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 155); in Helgoland 3 Muscids—1. Coelopa frigida *Fall.*; 2. Fucellia fucorum *Fall.*; 3. Scatophaga stercoraria *L.* ('Bl. u. Insekt. a. Helgoland,' p. 35).

Sickmann records the following for Osnabrück.—

Hymenoptera. (*a*) *Sphegidae*: 1. Astata minor *Kohl.*, freq.; 2. Cerceris labiata *F.*, do.; 3. C. quinquefasciata *Rossi*, do.; 4. Ceropales maculatus *F.*, do.; 5. Crabro alatus *Pz.*; 6. C. albilabris *F.*, very common; 7. C. armatus *v. d. L.* ♂; 8. C. brevis *v. d. L.*, freq.; 9. C. clypeatus *Schreb.*; 10. C. cribrarius *L.*, very common; 11. C. distinguendus *A. Mor.*; 12. C. elongatus *v. d. L.*, freq.; 13. C. exiguus *v. d. L.*, fairly freq.; 14. C. palmarius *Schreb.*, infreq.; 15. C. peltarius *Schreb.*, very common; 16. C. pygmaeus *v. d. L.*, rare; 17. C. scutellatus *Schev.*; 18. C. sexcinctus *F.*, freq.; 19. C. vagabundus *Pz.*, do.; 20. C. wesmaëli *v. d. L.*, infreq.; 21. Gorytes fallax *Handl.* ♀; 22. G. quadrifasciatus *F.*; 23. G. quinquecinctus *F.*, rare; 24. Mellinus sabulosus *F.*, freq.; 25. Mimesa equestris *F.*, very common; 26. Oxybelus bipunctatus *Oliv.*, freq.; 27. O. nigripes *Oliv.*, infreq.; 28. O. uniglumis *L.*, very common; 29. Pemphredon shuckardi *A. Mor.*, freq.; 30. Pompilus pectinipes *v. d. L.*, var. campestris *Wesm.*, freq.; 31. P. viaticus *L.*, very common; 32. P. wesmaëli *Thms.*, infreq.; 33. Psen atratus *Pz.*, very common;

34. Pseudagenia carbonaria *Scop.*, do.; 35. Salius affinis *v. d. L.*, rare; 36. S. exaltatus *F.*, very common; 37. S. notatus *Lep.*, freq.; 38. Trypoxylon figulus *L.*, do. (*b*) *Scoliidae*: 39. Tiphia femorata *F.*, very common; 40. T. minuta *v. d. L.*, infreq. (*c*) *Mutillidae*: 41. Myrmosa melanocephala *F.* ♂.

Friese noticed the following in the middle Saalthal.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena convexiuscula *K.*; 2. Bombus terrester *L.* (*b*) *Chrysididae*: 3. Chrysis callimorpha *Mocs.*; 4. C. fulgida *L.*; 5. C. inaequalis *Dahlb.*; 6. Splendidula *Rossi*; 7. C. succincta *L.*; 8. C. viridula *L.*; 9. Cleptes nitidulus *F.*; 10. Ellampus scutellaris *Pz.*; 11. Holopyga curvata *Forst.* (*c*) *Ichneumonidae*: 12. Amblyteles oratorius (*F.*) *Wesm.*; 13. A. (Ctenichneumon) repentinus (*Gr.*) *Ths.*; 14. Hellwigia elegans *Gr.*; 15. Ichneumon leucamelas (*F.*) *Wesm.*; 16. I. (Protichneumon) similatorius (*F.*) *Ths.*; 17. Lissonota maculatoria *Rossi*; 18. Microcryptus curvus (*Gr.*) *Tho.* (*d*) *Mutillidae*: 19. Mutilla rufipes *F.*, var. nigra *Rossi.* (*e*) *Scoliidae*: 20. Scolia quadripunctata *F.* (*f*) *Sphegidae*: 21. Astata boops *Schr.*; 22. Didineis lunicornis *F.*; 23. Gorytes levis *Ltr.*; 24. Nysson maculatus *F.* (*g*) *Tenthredinidae*: 25. Allantus marginellus *F.*; 26. Cladius pectinicornis *Fourcr.*; 27. Cyphona furcata *Vill.*

Burkill records the following for the east coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Crepidodera ferruginea *Scop.* (*b*) *Nitidulidae*: 2. Cercus rufilabris *Ltr.*; 3. Meligethes picipes *Sturm.* (*c*) *Staphylinidae*: 4. Tachyporus obtusus *L.* **B. Diptera.** (*a*) *Muscidae*: 5. Anthomyia brevicornis *Ztt.*; 6. A. radicum *L.*, very common; 7. Calliphora erythrocephala *Mg.*, skg.; 8. C. vomitoria *L.*, do.; 9. Hydrellia griseola *Fall.*; 10. Lucilia cornicina *F.*; 11. L. sylvarum *Mg.*; 12. L. splendida *Mg.*; 13. Morellia sp.; 14. Oscinis frit *L.*; 15. Pollenia rudis *F.*; 16. Sarcophaga, 2 sps.; 17. Drosophila graminum *Fall.*; 18. Scatophaga stercoraria *L.*, skg.; 19. Sepsis cynipsea *L.* (*b*) *Phoridae*: 20. Phora sp. (*c*) *Syrphidae*: 21. Eristalis arbustorum *L.*, skg.; 22. E. pertinax *Scop.*, do.; 23. E. tenax *L.*, do.; 24. Melanostoma scalare *F.*; 25. M. barbifrons *Fall.*; 26. Paragus sp.; 27. Platycheirus albimanus *F.*; 28. Sphaerophoria scripta *L.*; 29. Syritta pipiens *L.*, skg.; 30. Syrphus ribesii *L.*, do. (*d*) *Chironomidae*: 31. Ceratopogon niger *Winn.* (*e*) *Psychodidae*: 32. Pericoma sp. (*f*) *Mycetophilidae*: 33. Sciara sp., freq. **C. Hymenoptera.** (*a*) *Apidae*: 34. Bombus hortorum *L.*, one, skg. (*b*) *Formicidae*: 35. Formica fusca *L.*, skg.; 36. Myrmica rubra *L.*, do. (*c*) *Ichneumonidae*: 37. 25 undetermined sps. (*d*) *Sphegidae*: 38. Priocnemis pusillus *Schjödte.* (*e*) *Tenthredinidae*: 39. Allantus arcuatus *Forst.*, skg.

Herm. Müller gives the following list ('Fertilisation,' pp. 285–6; 'Weit. Beob.,' I, p. 307) for himself (H. M.) and Buddeberg (Budd.).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia armata *Hbst.* (H. M.); 2. S. bifasciata *Müller* (H. M.). (*b*) *Cleridae*: 3. Trichodes apiarius *L.*, nect-lkg., (Budd.). (*c*) *Coccinellidae*: 4. Coccinella mutabilis *Scriba*, nect-lkg. (Budd.); 5. C. quinquepunctata *L.*, do. (H. M.). (*d*) *Curculionidae*: 6. Spermophagus cardui *Stev.* (H. M.). (*e*) *Dermestidae*: 7. Anthrenus pimpinellae *F.* (H. M.). (*f*) *Elateridae*: 8. Agriotes gallicus *Lac.* (H. M.); 9. A. sputator *L.* (H. M.); 10. A. ustulatus *Schall.* (H. M.). (*g*) *Scarabaeidae*: 11. Trichius fasciatus *L.* (H. M.). (*h*) *Telephoridae*: 12. Danacea pallipes *Pz.* (H. M.); 13. Telephorus melanurus *F.*, in copulâ, nect-lkg. (H. M.). (*i*) *Mordellidae*: 14. Mordella aculeata *L.* (H. M.); 15. M. fasciata *F.* (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 16. Anthrax flava *Mg.* (H. M.). (*b*) *Muscidae*: 17. Gymnosoma rotundata *L.* (H. M.); 18. Species of Lucilia (H. M.); 19. Phasia crassipennis *F.* (Budd.); 20. Sarcophaga albiceps *Mg.* (H. M.); 21. Species of Sepsis (H. M.). (*c*) *Stratiomyidae*: 22. Stratiomys

chamaeleon *Deg.*, freq. (H. M.); 23. S. riparia *Mg.*, do. (H. M.). (*d*) *Syrphidae*: 24. Ascia podagrica *F.* (H. M.); 25. Cheilosia barbata *Loew*, skg. (H. M.); 26. C. soror *Zett.* (H. M.); 27. C. variabilis *Pz.*, skg. (Budd.); 28. Chrysogaster viduata *L.* (H. M.); 29. Eristalis arbustorum *L.* (H. M.); 30. E. sepulcralis *L.* (H. M.); 31. Helophilus floreus *L.* (H. M.); 32. Melithreptus scriptus *L.* (H. M.); 33. Pipiza funebris *F.* (H. M.); 34. Pipizella annulata *Macq.* (H. M.); 35. Syritta pipiens *L.* (H. M.); 36. Syrphus pyrastri *L.* (H. M.). **C. Hemiptera.** 37. Graphosoma nigrolineata *F.* freq. (H. M.). **D. Hymenoptera.** (*a*) *Apidae*: 38. Andrena nana *K.* ♀, skg. (H. M.); 39. A. parvula *K.* (H. M.); 40. Halictus albipes *F.* ♂ (H. M.); 41. H. levis *K.* ♂ (H. M.); 42. H. interruptus *Pz.* ♀ (H. M.); 43. Nomada lateralis *Pz.* ♀ (H. M.); 44. Prosopis sinuata *Schenck* ♂ (H. M.); 45. P. variegata *F.* ♂ (H. M.); 46. Specodes gibbus *L.* (H. M.). (*b*) *Chrysididae*: 47. Hedychrum lucidulum *F.* ♂ and ♀, freq. (H. M.). (*c*) *Ichneumonidae*: 48. Various sp. (H. M.). (*d*) *Sphegidae*: 49. Cerceris variabilis *Schr.* ♀ (H. M.); 50. Ceropales maculatus *F.* (H. M.). (*e*) *Mutillidae*: 51. Mutilla europaea *L.* ♂ (H. M.); 52. Oxybelus bipunctatus *Oliv.* (H. M.); 53. O. uniglumis *L.*, freq. (H. M.); 54. Pompilus intermedius *Schenck* (H. M.); 55. P. neglectus *Dahlb.* ♂ (H. M.); 56. P. niger *F.* ♂ (H. M.); 57. P. viaticus *L.* ♂ (H. M.); 58. Priocnemis obtusiventris *Schjödte* (H. M.). (*f*) *Scoliidae*: 59. Tiphia femorata *F.*, numerous (H. M.). (*g*) *Tenthredinidae*: 60. Allantus nothus *Klg.* (H. M., Budd.); 61. Athalia rosae *L.* (H. M.); 62. Hylotoma femoralis *Klg.* (H. M.); 63. H. rosarum *Klg.*, nect-lkg. (Budd.); 64. H. ustulata *L.* (H. M.); 65. Selandria serva *F.* (H. M.). (*h*) *Vespidae*: 66. Odynerus sinuatus *F.* ♀ (H. M.). **E. Lepidoptera.** (*a*) *Rhopalocera*: 67. Hesperia lineola *O.*, skg. (H. M.); 68. Spilothyrus alceae *Esp.* (Budd.). (*b*) *Tineidae*: 69. Nemotois *Hbn.* sp., skg. (H. M.). **F. Neuroptera.** *Planipennia*: 70. Hemerobius (H. M.).

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), a beetle and 2 Lepidoptera ('Alpenblumen,' p. 122). Wüstnei (island of Alsen), the bee Halictus nitidiusculus *K.* Alfken (Bremen), 3 bees (1. Andrena austriaca *Pz.* ♀ and ♂; 2. A. hattorfiana *F.* ♂; 3. A. parvula *K.* ♀), and 3 saw-flies (1. Allantus omissus *Först.*; 2. Poecilostoma luteolum *Klg.*; 3. Tenthredo coryli *Pz.*). Krieger (Zwickau), the rare fossorial wasp Nysson dimidiatus *Jur.* Schmiedeknecht (Thuringia), 4 bees (1. Andrena austriaca *Pz.*; 2. A. combinata *Chr.*; 3. A. lucens *Imh.*; 4. A. nana *K.*). Loew in Brandenburg (B.) and Mecklenburg (M.) ('Beiträge,' p. 36).—**A. Diptera.** *Muscidae*: 1. Xysta cana *Mg.*, skg. (M.). **B. Hymenoptera.** (*a*) *Ichneumonidae*: 2. Undetermined sp. (M.). (*b*) *Sphegidae*: 3. Cerceris interrupta *Pz.* ♀, skg. (B.); 4. Mellinus sabulosus *F.*, do. (M.): in Silesia, the hover-fly Eristalis horticola *Deg.*, skg.: in Steiermark (op. cit., p. 48), a Muscid (Phasia analis *F.*) and a bee (Andrena parvula *K.* ♀, po-cltg.): in Switzerland (op. cit., p. 55).—**A. Coleoptera.** (*a*) *Cerambycidae*: 1. Leptura sanguinolenta *L.* (*b*) *Cleridae*: Trichodes apiarius *L.* **B. Diptera.** (*a*) *Stratiomyidae*: 3. Stratiomys longicornis *Scop.* ♀, var. (*b*) *Syrphidae*: 4. Cheilosia impressa *Lw.*; 5. Syrphus lasiophthalmus *Zett.*; 6. S. umbellatarum *F.* (*c*) *Tabanidae*: 7. Tabanus auripilus *Mg.*, var. aterrimus *Mg.* ♀; 8. T. infuscatus *Lw.* Schenck (Nassau).—**Hymenoptera.** *Apidae*: 1. Andrena austriaca *Pz.*; 2. A. nana *K.*; 3. Prosopis variegata *F.* (*b*) *Sphegidae*: 4. Ceropales maculatus *F.*; 5. C. variegatus *F.*; 6. Gorytes levis *Ltr.*; 7. Tachysphex pectinipes *L.* (*c*) *Mutillidae*: 8. Mutilla rufipes *F.*, var. nigrita *Pz.* F. F. Kohl (Tyrol), the true wasp Odynerus parietum *L.*, and the fossorial wasp Crabro arbitrarius *L.* Handlirsch, 2 fossorial wasps (Gorytes levis *Ltr.*, and G. quadrifasciatus *F.*). Schiner (Austria), a Syrphid (Cheilosia impressa *Lw.*), and 6 Muscids (1. Alophora hemiptera *F.*; 2. Clairvillia ocypterina *R.-D.*; 3. Germaria ruficeps *F.*; 4. Miltogramma ruficornis *Mg.*; 5. Plesina nigrisquama *Zett.*; 6. Siphona geniculata *Deg.*). MacLeod (Flanders), 9 short-tongued Hymenoptera, 5 Syrphids, 3 other flies, 2 beetles, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 278–9). H. de Vries (Netherlands), the fossorial wasp

Ceropales maculatus *F.*, and the Scoliid Tiphia femorata *F.* ♂ and ♀ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). Heinsius (Holland), a Stratiomyid (Stratiomys furcata *F.* ♀), and 4 beetles (1. Agriotes obscurus *L.*; 2. Cistela sulphurea *L.*; 3. Coccinella septempunctata *L.*; 4. Cantharis fulva *Scop.* (=Telephorus melanurus *F.*)) (Bot. Jaarb. Dodonaea, Ghent, iv, 1892, p. 59). MacLeod (Pyrenees), 12 Hymenoptera, 4 beetles, and 7 flies (op. cit., iii, 1891, p. 407). Saunders (England), the Scoliid Tiphia femorata *F.*

370. **Orlaya** Hoffm.

1181. **O. glandiflora** Hoffm. (=Daucus grandiflorus *Scop.*). (Herm. Müller, 'Weit. Beob.,' I, pp. 307–10; Schulz, 'Beiträge,' II, pp. 86, 91–2, 190.)—This white-flowered species is andromonoecious, according to Schulz, but Hermann Müller says that it may also be gynomonoecious. The hermaphrodite flowers are homogamous. *The central flowers of the umbellules are male, with vestigial ovaries, but* neither styles nor stigmas; their petals are small and incurved. The marginal flowers are hermaphrodite, or sometimes (Herm. Müller) fertile female ones; the external petal is enlarged. Sometimes the reproductive organs of male, female, and hermaphrodite flowers are completely abortive. In each flower at the margin of an entire umbel the external petal is enlarged into a deeply bifid expansion over 1 cm. long.

Although the plant grows among corn, it is very conspicuous, owing to the large marginal flowers, and the inflorescences are visited by many insects, which effect the crossing of different umbels and frequently of different stocks, if they alight on the margins of the umbels. Schulz says that automatic self-pollination is possible only for a short time in the homogamous hermaphrodite flowers, as the stamens quickly bend outwards.

Visitors.—Schulz (Tyrol) noticed numerous flies and beetles, more rarely small Hymenoptera.

Herm. Müller observed the following in Thuringia.—

A. Diptera. (*a*) *Bombyliidae*: 1. Ploas grisia *F.*, skg. (*b*) *Empidae*: 2. Empis livida *L.*, skg. (*c*) *Syrphidae*: 3. Syritta pipiens *L.*, freq. (*d*) *Muscidae*: 4. Species of Anthomyia; 5. Gymnosoma rotundata *L.*, skg.; 6. Ocyptera brassicaria *F.*, do.; 7. Ulidia erythrophthalma *Mg.*, in great numbers, skg. **B. Coleoptera.** (*a*) *Telephoridae*: 8. Danacea pallipes *Pz.*, nect-lkg.; 9. Dasytes subaeneus *Schh.* (*b*) *Mordellidae*: 10. Mordella fasciata *F.*, numerous, nect-lkg. (*c*) *Curculionidae*: 11. Spermophagus cardui *Stev.* (*d*) *Cerambycidae*: 12. Strangalia bifasciata *Müll.*, nect-lkg. **C. Hymenoptera.** (*a*) *Formicidae*: 13. Several sps. (*b*) *Apidae*: 14. Halictus maculatus *Sm.* ♀, po-cltg. **D. Lepidoptera.** *Rhopalocera*: 15. Coenonympha pamphilus *L.*, skg.

F. F. Kohl (Tyrol) records 3 ruby-wasps (1. Chrysis rutilans *Oliv.*; 2. C. scutellaris *F.*; 3. Hedychrum regium *F.*), and 10 true wasps (1. Polistes gallica *L.*; 2. Eumenes pomiformis *F.*; 3. E. coarctata *L.*; 4. E. unguiculata *Vill.*; 5. Ancistrocerus parietum *L.*; 6. Leionotus simplex *F.*; 7. L. dantici *Rossi*; 8. L. parvulus *Lep.*; 9. L. chevrieranus *Sauss.*; 10. L. tarsatus *Sauss.*

Schletterer observed the following at Pola and in the Tyrol.—

Hymenoptera. (*a*) *Apidae*: 1. Andrena aeneiventris *Mor.* (*T.*); 2. Ceratina cucurbitina *Rossi*; 3. Halictus villosulus *K.*; 4. Prosopis clypearis *Schenck*; 5. P. hyalinata *Sm.* (=P. corvina *Först.*); 6. P. variegata *F.* (*b*) *Chrysididae*:

7. Chrysis cuprea *Rossi*; 8. C. refulgens *Spin.*; 9. C. viridula *L.*; 10. Ellampus auratus *L.*; 11. Stilbum cyanurum *Först.* (=S. calens *F.*). (*c*) *Evaniidae*: 12. Gasteruption granulithorax *Tourn.* (*d*) *Ichneumonidae*: 13. Colpagnathus celerator *Gr.*; 14. Ichneumon xanthorius *Först.* (*e*) *Pompilidae*: 15. Pompilus tripunctatus *Dahlb.*; 16. P. viaticus *L.*; 17. Pseudagenia carbonaria *Scop.*; 18. Salius fuscus *F.* (*f*) *Scoliidae*: 19. Scolia insubrica *Scop.*; 20. S. quadripunctata *F.*; 21. Tiphia morio *F.* (*g*) *Sphegidae*: 22. Cerceris emarginata *Pz.*; 23. C. quadrifasciata *Pz.* (*h*) *Tenthredinidae*: 24. Amasis laeta *F.* (*i*) *Vespidae*: 25. Polistes gallica *L.*

371. **Caucalis** L.

1182. **C. daucoides** L. (Schulz, 'Beiträge,' II, pp. 91, 94, 190; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 296, 311, 342.)—According to Schulz, this white-flowered species is andromonoecious, with homogamous or more rarely slightly protandrous hermaphrodite flowers. The male flowers are usually in the middle of the umbels and umbellules. The terminal umbel generally possesses the largest number of hermaphrodite flowers, and self-pollination may easily take place.

Kerner describes the flowers as protogynous. He says that the central umbellules contain only pseudo-hermaphrodite male flowers, while each of the others possesses 4–7 of these and two really hermaphrodite flowers. Self-pollination is brought about by an incurving of the bent filaments.

Visitors.—Herm. Müller saw the bug Graphosoma nigrolineatum *F.* in Thuringia ('Weit. Beob.,' I, p. 306).

Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Chrysididae*: 1. Chrysis succincta *L.* (*b*) *Evaniidae*: 2. Gasteruption kriechbaumeri *Schlett.* (*c*) *Ichneumonidae*: 3. Mesoleius cruralis *Gr.* (*d*) *Tenthredinidae*: 4. Cephus variegatus *Stein.*

372. **Turgenia** Hoffm.

1183. **T. latifolia** Hoffm. (=Tordylium latifolium, and Caucalis latifolia *L.*).—According to Schulz ('Beiträge,' II, pp. 92, 191), this species is andromonoecious, with homogamous hermaphrodite flowers. The distribution of sexes is the same as in Caucalis.

Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 296, 342) also describes the flowers as protogynous. He says that in each umbellule there are 6–9 pseudo-hermaphrodite pollen flowers in the centre, and 5–8 actinomorphous hermaphrodite ones externally. Self-pollination is effected as in Caucalis daucoides.

373. **Torilis** Adans.

1184. **T. Anthriscus** Bernh. (=Tordylium Anthriscus *L.*, and Caucalis Anthriscus *Huds.*).—According to Schulz ('Beiträge,' I, p. 60), the flowers of this species, which are white, often tinged with red, are distributed andromonoeciously, the hermaphrodite ones being markedly protandrous. The short-stalked male flowers occupy the centre of all the umbellules, and in umbels of a higher order the number of male flowers increases. Tertiary and quaternary umbels occasionally include these only. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) says that at

Ruppin the umbellules of primary umbels bear marginal hermaphrodite and central male flowers; secondary ones possess a few marginal hermaphrodite and numerous central male flowers; tertiary umbels are completely or almost completely male.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) observed the following (Herm. Müller, 'Fertilisation,' p. 286; 'Weit. Beob.,' I, p. 307; 'Alpenblumen,' p. 122).—

A. Coleoptera. (*a*) *Malacodermata*: 1. Trichodes apiarius *L.*, nect-lkg. (H. M.). **B. Diptera.** (*a*) *Dolichopodidae*: 2. Gymnopternus germanus *Wiedem.*, nect-lkg. (H. M.). (*b*) *Muscidae*: 3. Gymnosoma rotundata *L.*, in large numbers (H. M.). (*c*) *Syrphidae*: 4. Ascia podagrica *F.*, nect-lkg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 5. Prosopis variegata *F.* ♂ (H. M.). (*b*) *Sphegidae*: 6. Cerceris quinquefasciata *Rossi* ♂, nect-lkg. (Budd.); 7. Ceropales maculata *F.* ♂ and ♀, numerous (H. M.); 8. Crabro cribrarius *L.* ♂ (H. M.); 9. C. sp. (H. M., Alps), nect-lkg.; 10. C. vagus *L.* ♀ (H. M.); 11. Oxybelus bellicosus *Ol.* (H. M.); 12. O. uniglumis *L.*, numerous (H. M.). (*c*) *Tenthredinidae*: 13. Tenthredo notha *Kl.* (Budd.). (*d*) *Vespidae*: 14. Odynerus parietum *L.* (H. M.). **D. Lepidoptera.** 15. Pieris rapae *L.* (H. M.).

Willis ('Fls. and Insects in Gt. Britain,' Part I) gives the following for the neighbourhood of the south coast of Scotland, all skg.—

A. Diptera. (*a*) *Muscidae*: 1. Agromyza flaveola *Fall.*; 2. Anthomyia radicum *L.*; 3. Hylemyia strigosa *F.*; 4. Phorbia floccosa *Macq.*; 5. Stomoxys calcitrans *L.* (*b*) *Syrphidae*: 6. Platycheirus albimanus *F.* **B. Hemiptera.** 7. Anthocoris sp. **C. Hymenoptera.** (*a*) *Apidae*: 8. Halictus sp. (*b*) *Ichneumonidae*: 9. 4 undetermined species. **D. Lepidoptera.** (*a*) *Noctuidae*: 10. Plusia gamma *L.* (*b*) *Rhopalocera*: 11. Epinephele janira *L.* (*c*) *Microlepidoptera*: 12. Simaëthis fabriciana *Steph.*

The following were recorded by the observers, and for the localities stated.—

Loew (Mecklenburg), the true wasp Vespa sylvestris *Scop.* ♂, skg. ('Beiträge,' p. 38). Alfken (Bremen), **A. Coleoptera.** (*a*) *Chrysomelidae*: 1. Lema duodecimpunctata *L.* (*b*) *Telephoridae*: 2. Malachius aeneus *L.* **B. Hymenoptera.** (*a*) *Tenthredinidae*: 3. Allantus temulus *Scop.*; 4. Arge enodis *L.*; 5. A. ustulata *L.*; 6. Dolerus fissus *Htg.*; 7. Macrophya quadrimaculata *F.*; 8. Pachyprotasis rapae *L.* Sickmann (Osnabrück), the parasitic fossorial wasp Ceropales maculatus *F.* MacLeod (Flanders), 3 short-tongued Hymenoptera, 5 hover-flies, 4 Muscids, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 279–80).

1185. **T. nodosa** Gaertn. (=Caucalis fallax *Boiss. et Balansa*).—

Visitors.—Schletterer (Pola) observed a ruby-wasp (Ellampus auratus *L.*), 2 ichneumon flies (Acaenitis fulvicornis *Gr.*, and Anisobus sp.), and a saw-fly (Argae rosae *L.*).

1186. **T. infesta** Roth (=Caucalis infesta *Vest.*).—According to Schulz ('Beiträge,' II, pp. 91, 191), this species is andromonoecious, with homogamous or slightly protandrous hermaphrodite flowers, in which self-pollination can easily take place.

Visitors.—MacLeod (Pyrenees) observed a Muscid (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 407); Schletterer (Pola) saw the ichneumon fly Glypta pictipes *Taschenb.*

374. Scandix L.

1187. **S. Pecten-Veneris** L. (Schulz, 'Beiträge,' II, pp. 91, 94, 191; Kirchner, 'Flora v. Stuttgart,' p. 394; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 280–2; Kerner, 'Nat. Hist. Pl., Eng. Ed. 1, II, p. 342; Knuth, 'Bloemenbiol. Bijdragen.')—According to Schulz, Kirchner, and MacLeod, the small white flowers of this species are distributed andromonoeciously, and the hermaphrodite ones are homogamous or slightly protandrous. The long-stalked male flowers possess no trace of a pistil; they are usually in the middle of the umbellules, but the primary umbels often contain hermaphrodite flowers only, while the tertiary ones are frequently composed of nothing but male flowers; the number of the latter is generally greater in umbels of high order. Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896) states that in Brandenburg all the umbels are hermaphrodite to begin with, but become more or less female by the partial or complete degeneration of the anthers. The anthers are greenish-yellow in colour; the pollen-grains white, ovoid, not constricted in the middle, with 3 longitudinal grooves, about 13 μ broad and 30 μ long.

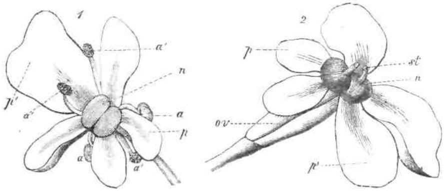


FIG. 166. *Anthriscus sylvestris, Hoffm.* (after Herm. Müller). (1) Flower in the first (purely male) stage. *a*, immature anthers, hanging out of the flower; *a'*, mature anthers, projecting obliquely upwards. The styles are not yet visible. (2) Flower in the second (purely female) stage. The stamens have dropped off, the styles have developed, and their stigmas (*st*) are mature. *n*, nectary; *ov*, ovary; *p*, inner petal; *p'*, outer petal.

Self-pollination readily takes place, and Kerner says it is brought about by incurving of the filaments, resulting in the anthers being applied to the stigmas. The same authority describes the flowers as protogynous.

VISITORS.—On the island of Fehmarn (adjoining 'Land Oldenburg') I only noticed a hover-fly (Eristalis tenax *L.*), po-dvg.; MacLeod (Flanders) saw a fossorial wasp and 3 Diptera (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 282).

375. Anthriscus Bernh.

1188. **A. sylvestris** Hoffm. — Warming, Kirchener, Kerner, Schulz, and MacLeod describe this white-flowered species as andromonoecious, with markedly protandrous hermaphrodite flowers. The inner flowers of the umbellules are male, the outer ones hermaphrodite, and Schulz says that the number of the former increases in umbels of higher order. MacLeod (Bot. Jaarb. Dodonaea, Ghent, vi, 1894) gives a full account of these relations. According to Schröter (Justs bot.

Jahresber., Leipzig, xvii, (1889) 1891, p. 557), the whole plant is protandrous, all the flowers of the same stock being at the same time first male, then neuter, and finally female. Kerner, on the other hand, observed the same kind of geitonogamy as in Sium and Foeniculum (*q. v.*).

VISITORS.—Herm. Müller gives the following list for himself (H. M.), Buddeberg (Budd.), and Borgstette (Borg.) ('Fertilisation,' pp. 280–1, 'Weit. Beob.,' I, p. 310).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.* (H. M.); 2. Leptura livida *F.* (Borg.); 3. Grammoptera ruficornis *F.* (H. M.); 4. Pachyta collaris *L.* (H. M.); 5. P. octomaculata *F.* (H. M.). (*b*) *Cistelidae*: 6. Cistela murina *L.* (H. M.). (*c*) *Cleridae*: 7. Trichodes apiarius *L.*, freq., nect-lkg. (H. M.). (*d*) *Coccinellidae*: 8. Coccinella quattuordecimpunctata *L.*, nect-lkg. (H. M.); 9. C. septempunctata *L.*, do. (H. M.). (*e*) *Curculionidae*: 10. Bruchus sp., numerous. (*f*) *Dermestidae*: 11. Anthrenus claviger *Er.*, freq., nect-lkg. (H. M.); 12. A. scrophulariae *L.*, do. (H. M.); 13. Tiresias serra *F.*, do. (H. M.). (*g*) *Elateridae*: 14. Athous niger *L.* (H. M.); 15. Corymbites quercus *Ol.* (H. M.); 16. Lacon murinus *L.*, several (H. M.); 17. Synaptus filiformis *F.* (H. M.). (*h*) *Telephoridae*: 18. Anthocomus fasciatus *F.*, freq., nect-lkg. (H. M.); 19. Axinotarsus publicarius *F.*, nect-lkg. (H. M.); 20. Malachius aeneus *L.* (H. M.); 21. M. bipustulatus *L.* (H. M.); 22. Telephorus fuscus *L.* (H. M.); 23. T. lividus *L.* (H. M.); 24. T. rusticus *Fall.* (H. M.). (*i*) *Mordellidae*: 25. Mordella fasciata *F.* (H. M.); 26. M. pumila *Gyll.* (H. M.). (*k*) *Nitidulidae*: 27. Epuraea sp. (H. M.); 28. Meligethes sp. (H. M.). **B. Diptera.** (*a*) *Bibionidae*: 29. Bibio hortulanus *L.* (H. M.). (*b*) *Chironomidae*: 30. Ceratopogon sp., skg. (H. M.). (*c*) *Empidae*: 31. Empis punctata *F.* (H. M.); 32. E. stercorea *L.* (H. M.). (*d*) *Muscidae*: 33. Echinomyia fera *L.* (H. M.); 34. Graphomyia maculata *Scop.* (H. M.); 35. Lucilia sericata *Mg.* (H. M.); 36. Musca corvina *F.* (H. M.); 37. Platystoma seminationis *F.* (H. M.); 38. Psila fimetaria *L.* (H. M.); 39. Sarcophaga sp. (H. M.); 40. Scatophaga merdaria *F.* (H. M.); 41. S. stercoraria *L.*, numerous (H. M.); 42. Sepsis sp. (H. M.); 43. Zophomyia tremula *Scop.* (H. M.). (*e*) *Stratiomyidae*: 44. Nemotelus pantherinus *L.* (H. M.); 45. Stratiomys chamaeleon *Deg.* (H. M.). (*f*) *Syrphidae*: 46. Ascia podagrica *F.* (H. M.); 47. Eristalis arbustorum *L.* (H. M.); 48. E. pertinax *Scop.* (H. M.); 49. Helophilus floreus *L.* (H. M.); 50. Melithreptus pictus *Mg.* (H. M.); 51. M. scriptus *L.* (H. M.); 52. Syritta pipiens *L.* (H. M.); 53. Syrphus corollae *F.* (H. M.); 54. S. ribesii *L.* (H. M.); 55. Xylota lenta *Mg.* (Borg.) (*g*) *Tipulidae*: 56. Pachyrhina crocata *L.* (H. M.); 57. P. pratensis *L.* (H. M.). **C. Hemiptera.** 58. Systellonotus triquitatus *L.*, skg. (H. M.). **D. Hymenoptera.** (*a*) *Apidae*: 59. Andrena collinsonana *K.* ♀ (H. M.); 60. A. dorsata *K.* ♀, po-cltg. (H. M.); 61. A. fucata *Sm.* ♀ (H. M.); 62. A. parvula *K.*, skg. and po-cltg. (H. M.); 63. Apis mellifica *L.* ☿, po-cltg. (H. M.); 64. Chelostoma campanularum *K.* ♀ and ♂, nect-lkg. (H. M.); 65. Colletes daviesanus *K.* ♂, skg. (H. M.); 66. Halictus smeathmanellus *K.* ♀ (H. M.); 67. Prosopis annularis *Sm.* ♀, nect-lkg. (H. M.). (*b*) *Braconidae*: 68. Microgaster sp., nect-lkg. (H. M.). (*c*) *Cynipidae*: 69. Eucoda subnebulosa *Gir.* (*teste* Schenck) ♀ (H. M.). (*d*) *Formicidae*: 70. Various species. (*e*) *Ichneumonidae*: 71. do. (*f*) *Sphegidae*: 72. Crabro cephalotes *F.* ♂ (H. M.); 73. C. sexcinctus *F.* ♂ (H. M.); 74. Gorytes laticinctus *Lep.* ♀ (H. M.); 75. Pompilus neglectus *Dahlb.* ♀ (H. M.); 76. P. viaticus *L.* ♀ (H. M.); 77. Psen atratus *Pz.* ♀, nect-lkg. (H. M.). (*g*) *Tenthredinidae*: 78. Abia sericea *L.*, in large numbers (H. M.); 79. Allantus nothus *Klg.* (H. M.); 80. Amauronematus vittatus *Lep.* (H. M.); 81. Athalia annullata *F.* (H. M.); 82. A. rosae *L.* (H. M.); 83. Dolerus fissus *Htg.* (H. M.); 84. Hylotoma femoralis *Klg.* (H. M.); 85. H. rosarum *Klg.*, nect-lkg. (H. M.); 86. Macrophya neglecta *Klg.* (H. M.); 87. M. rustica *L.* (H. M.); 88. Pachyprotasis rapae *Kl.* (H. M.); 89. Pteronus myosotidis *F.* (H. M.); 90. Selandria serva *F.*

(H. M.); 91. Tenthredo sp. (H. M.). (*h*) *Vespidae*: 92. Odynerus elegans *H.-Sch.* ♀ (Borg.). **E. Lepidoptera.** (*a*) *Rhopalocera*: 93. Thecla betulae *L.* (Budd.). (*b*) *Tortricidae*: 94. Grapholitha compositella *F.*, skg. (H. M.). **F. Neuroptera.** *Planipennia*: 95. Hemerobius sp. (H. M.); 96. Panorpa communis *L.*, nect-lkg. (H. M.); 97. Sialis lutaria *L.* (H. M.).

Alfken records the following for Bremen.—

A. Diptera. (*a*) *Muscidae*: 1. Platystoma seminationis *F.* (*b*) *Bibionidae*: 2. Bibio marci *L.*; 3. Dilophus vulgaris *Mg.* (*c*) *Syrphidae*: 4. Eristalis sepulcralis *L.*; 5. Rhingia rostrata *L.*; 6. Xylota ignava *Pz.* **B. Hymenoptera.** (*a*) *Apidae*: 7. Andrena albicans *Müll.* ♀; 8. A. chrysosceles *K.* ♀, rare; 9. A. labialis *K.* ♂; 10. A. nitida *Fourcr.* ♀ po-cltg., ♂ skg., rare; 11. A. parvula *K.*, very common, ♀ po-cltg. and skg., ♂ skg.; 12. A. proxima *K.*, freq., ♀ skg. and po-cltg., ♂ skg. (*b*) *Ichneumonidae*: 13. Alomya ovator *F.* ♀ and ♂; 14. Ichneumon extensorius *L.*; 15. I. fabricator *F.*; 16. Tryphon trochanteratus *Hgr.* (*c*) *Sphegidae*: 17. Crabro chrysostomus *Lep.* ♂, freq.; 18. C. nigritus *Lep.* ♂, rare; 19. C. planifrons *Thms.* ♀, rare; 20. C. vagabundus *Pz.* ♂, not infreq.; 21. Psen concolor *Dahlb.* ♀, do. (*d*) *Tenthredinidae*: 22. Athalia glabricollis *Ths.*; 23. A. lugens *Klg.*; 24. A. rosae *L.*; 25. A. spinarum *F.*; 26. Poecilostoma luteola *Klg.*; 27. Pteronus myosotidis *F.*; 28. Selandria serva *F.*; 29. Tenthredo atra *L.*; 30. Tenthredopsis gibberosa *Knw.* (*e*) *Vespidae*: 31. Odynerus oviventris *Wesm.* ♂, infreq.; 32. O. parietum *L.* ♀ and ♂, freq.; 33. O spinipes *L.* ♂, do.

Verhoeff saw the following in Norderney.—

A. Coleoptera. (*a*) *Elateridae*: 1. Athous haemorrhoidalis *F.* (*b*) *Telephoridae*: 2. Cantharis fusca *L.*; 3. Dasytes plumbeus *Müll.* (*c*) *Mordellidae*: 4. Anaspis flava *L.* (*d*) *Nitidulidae*: 5. Brachypterus gravidus *Ill.*; 6. Epurea aestiva *L.*; 7. Meligethes aeneus *L.*; 8. M. coracinus *Sturm.* (*e*) *Curculionidae*: 9. Phyllobius urticae *Deg.* **B. Diptera.** (*a*) *Bibionidae*: 10. Bibio sp. (*b*) *Chironomidae*: 11. Chironomus sp. (*c*) *Dolichopodidae*: 12. Dolichopus aeneus *Deg.*; 13. D. brevipennis *Mg.* (*d*) *Empidae*: 14. Empis stercorea *L.*; 15. Hilaria quadrivittata *Mq.*; 16. Platypalpus flavipalpis *Mq.* (*e*) *Muscidae*: 17. Anthomyia muscaria *Zett.*; 18. A. sp.; 19. Aricia incana *Wiedem.*; 20. Calliphora erythrocephala *Mg.*; 21. Chlorops sp.; 22. Cynomyia mortuorum *L.* ♂; 23. Cyrtoneura hortorum *Fall.* ♂; 24. Dryomyza anilis *Fall.*; 25. Hylemyia conica *Wiedem.*, ♂; 26. Lucilia caesar *L.*; 27. Musca domestica *L.*; 28. Myospila meditabunda *F.* ♂ and ♀; 29. Nemopoda sp.; 30. Onesia floralis *R.-D.* ♂ and ♀; 31. Psila villosula *Mg.*; 32. Sapromyza rorida *Fall.*; 33. Scatophaga lutaria *F.*; 34. S. stercoraria *L.* ♂; 35. Sepsis cynipsea *L.*; 36. Spilogaster duplicata *Mg.* ♂; 37. S. vespertina *Fall.* ♂. (*f*) *Syrphidae*: 38. Eristalis arbustorum *L.*; 39. Helophilus pendulus *L.*; 40. Platycheirus albimanus *F.* ♀; 41. Syritta pipiens *L.*; 42. Syrphus corollae *F.* ♀ and ♂. (*g*) *Therevidae*: 43. Thereva anilis *L.*, a ♂. (*h*) *Tipulidae*: 44. Ptychoptera contaminata *L.* **C. Hymenoptera.** (*a*) *Chalcididae*: 45. Torymus sp. (*b*) *Formicidae*: 46. Lasius niger *L.* (*c*) *Tenthredinidae*: 47. Pteronus monticola *Ths.*

Loew noticed the following in Brandenburg (B.), Rügen (R.), and Mecklenburg (M.) ('Beiträge,' p. 35).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Pachyta collaris *L.* (B.). (*b*) *Chrysomelidae*: 2. Crioceris duodecimpunctata *L.* (B.). (*c*) *Dermestidae*: 3. Anthrenus scrophulariae *L.* (B.). (*d*) *Scarabaeidae*: 4. Cetonia floricola *Hbst.* (=C. metallica *F.*) (B.). (*e*) *Telephoridae*: 5. Rhagonycha testacea *L.* (B.); 6. Telephorus fulvicollis *F.* (B.); 7. T. fuscus *L.* (B.); 8. T. obscurus *L.* (B.); 9. T. rufus *L.* (B.); 10. T. rusticus *Fall.* (B.). **B. Diptera.** (*a*) *Bibionidae*: 11. Bibio hortulanus *F.* ♀ (B.). (*b*) *Dolichopodidae*: 12. Dolichopus sp. (B.). (*c*) *Empidae*: 13. Empis fallax *Egg.* (B.). (*d*) *Syrphidae*: 14. Melanostoma hyalinata *Fall.*, skg. (R.). **C. Hymenoptera.** (*a*) *Sphegidae*: 15. Crabro cetratus *Shuck.* ♀, skg. (B.);

16. C. vagus *L.* (B.); 17. Gorytes campestris *Müll.* ♀ and ♂, skg. (B.); 18. Nysson interruptus *F.* (B.); 19. Oxybelus uniglumis *L.* ♀ and ♂ (B.); 20. Pemphredon rugifer *Dahlb.* (B.). (*b*) *Tenthredinidae*; 21. Rhogogastera viridis *L.* (M.); 22. Tenthredo livida *L.* (M.). In Silesia (S.), Hesse (H.), Riesengebirge (R.), and the Harz (Hr.) (op. cit., pp. 29, 47).—**A. Coleoptera.** (*a*) *Dermestidae*: 1. Anthrenus scrophulariae *L.* nect-lkg. (S.); 2. Byturus fumatus *F.*, do. (S.). (*b*) *Telephoridae*: 3. Rhagonycha melanura *F.* (S.). **B. Diptera.** (*a*) *Asilidae*: 4. Dioctria atricapilla *Mg.* (H.). (*b*) *Muscidae*: 5. Miltogramma germari *Mg.* (Hr.). (*c*) *Syrphidae*: 6. Chrysotoxum fasciolatum *Deg.* (S.); 7. Microdon devius *L.* (H.); 8. Spilomyia diophthalma *L.*, skg. (S.); 9. Volucella pellucens *L.* (R.). (*d*) *Tabanidae*: 10. Tabanus micans *Mg.* (H.). **C. Hymenoptera.** (*a*) *Sphegidae*: 11. Crabro wesmaëli *v. d. L.* ♀ and ♂, skg. (S.). (*b*) *Vespidae*: 12. Vespa rufa *L.* ☿, skg. (S.); 13. V. sylvestris *Scop.* ☿, skg. (S.). In Switzerland (S.) and the Tyrol (T.),—**A. Coleoptera.** (*a*) *Cerambycidae*: 1. Leptura sanguinolenta *L.* (T.); 2. Oxymirus cursor *L.* (T.); 3. Pachyta collaris *L.* (T.); 4. P. octomaculata *F.* (T.); 5. P. quadrimaculata *L.* (T.); 6. Strangalia armata *Hbst.* (T.); 7. S. attenuata *L.* (T.); 8. S. melanura *L.* (T.); 9. Toxotus meridianus *L.* (T.). (*b*) *Scarabaeidae*: 10. Hoplia praticola *Duft.* (T.); 11. Trichius fasciatus *L.* (T.). (*c*) *Telephoridae*: 12. Malachius bipustulatus *L.* (T.); 13. Rhagonycha terminalis *Redt.* (T.). **B. Diptera.** (*a*) *Stratiomyidae*: 14. Odontomyia viridula *F.* (T.). (*b*) *Syrphidae*: 15. Cheilosia decidua *Egg.* (?) (T.); 16. C. pigra *Loew.* (?) (T.); 17. Syrphus vittiger *Zett.* (T.). **C. Hymenoptera.** (*a*) *Chrysididae*: 18. Chrysis ignita *L.* (=C. angustula *Schenck*) (T.). (*b*) *Tenthredinidae*: 19. Allantus albicornis *F.* (T.); 20. Tenthredo flavicornis *F.* (T.). (*c*) *Vespidae*: 21. Leionotus simplex *F.* (T.); 22. Polistes gallica *L.* (S.).

The following were recorded by the observers, and for the localities stated.—

Knuth (Rügen), the Cerambycid Strangalia maculata *Poda*, and the bug Calocoris norvegicus *Gmel.* Friese (Mecklenburg), the cuckoo bee Nomada guttulata *Schenck*, infreq.; (Thuringia), 4 saw-flies—1. Allantus fasciatus *Scop.*; 2. A. koehleri *Klg.*; 3. A. marginellus *F.*; 4. A. temulus *Scop.* Sickmann (Osnabrück), the fossorial wasp Gorytes quadrifasciatus *F.*, occasional. Schmiedeknecht (Thuringia), the bee Andrena chrysosceles *K.* F. F. Kohl, the fossorial wasps Crabro cribrarius *L.* and C. scutellatus *Schev.* Handlirsch, the fossorial wasp Gorytes quadrifasciatus *F.* Schletterer (Pola), 2 bees (Halictus minutus *K.*, and Prosopis clypearis *Schenck*), and 2 ichneumon-flies (Amblyteles armatorius *Forst.*, and Pimpla examinator *F.*). H. de Vries (Netherlands), the saw-fly Dolerus haematodes *Schr.* (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). MacLeod (Flanders), 2 short-tongued Hymenoptera, 13 Diptera, and 3 beetles (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 285–6). Burkill (Yorkshire coast), the Muscid Sepsis nigripes *Mg.*, skg. ('Fertlsn. of Spring Fls.').

1189. A. nitida Garcke.—

Visitors.—Loew (Altvatergebirge, Silesia) observed an ichneumon-fly of undetermined species, and 2 saw-flies—Pamphilius hortorum *Klg.* and Tenthredopsis scutellaris *F.*

1190. A. Cerefolium Hoffm.—Warnstorf (Schr. natw. Ver., Wernigerode, xi, 1896) says that in this species the primary umbels bear hermaphrodite flowers, with vestigial anthers here and there; secondary ones usually possess only pseudo-hermaphrodite pollen flowers; rarely some of the marginal flowers are hermaphrodite, more frequently the anthers are partly degenerate. The pollen-grains are white, smooth, ovoid, with 3 furrows and a central constriction and band, about 15 μ broad and up to 35 μ long.

Visitors.—Herm. Müller observed the following ('Fertilisation,' p. 281).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Grammoptera ruficornis *F.*, nect-lkg. (*b*) *Dermestidae*: 2. Anthrenus pimpinellae *F.*, freq.; 3. A. scrophulariae *L.*, do. (*c*) *Mordellidae*: 4. Anaspis frontalis *L.* (*d*) *Nitidulidae*: 5. Meligethes, very common, nect-lkg. (*e*) *Telephoridae*: 6. Anthocomus fasciatus *L.*; 7. Malachius aeneus *L.* **B. Diptera.** (*a*) *Bibionidae*: 8. Bibio hortulanus *L.* (*b*) *Muscidae*: 9. Anthomyia radicum *L.*; 10. Cyrtoneura simplex *L.*; 11. Exorista vulgaris *Fall.*; 12. Gymnosoma rotundata *L.*; 13. Sarcophaga dissimilis *Mg.*; 14. S. haemorrhoa *Mg.*; 15. Sepsis sp., nect-lkg. (*c*) *Syrphidae*: 16. Eristalis arbustorum *L.*; 17. E. nemorum *L.*; 18. Syritta pipiens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 19. Apis mellifica *L.* ☿, po-cltg.; 20. Prosopis armillata *Nyl.* ♀; 21. P. communis *Nyl.* ♂. (*b*) *Formicidae*: 22. Several species. (*c*) *Ichneumonidae*: 23. Numerous species. (*d*) *Sphegidae*: 24. Oxybelus uniglumis *L.*, freq.; 25. P. pectinipes *L.* ♂; 26. P. spissus *Schjödte.*

The following were recorded by the observers, and for the localities stated.—

Schenck (Nassau), the bee Andrena proxima *K.* ♀, very freq. MacLeod (Flanders), a Muscid and a beetle (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 286). Schletterer (Pola), the ichneumon Limneria (Angilia) fenestralis (Hgr.) *Ths.*

1191. **A. vulgaris** Bernh. (=Scandix Anthriscus *L.*).—Schulz ('Beiträge,' II, pp. 89–91, 94) describes the small greenish-white flowers of this species as hermaphrodite and homogamous. Self-pollination inevitably results from incurving of the stamens: it is effective.

Visitors.—Flies, occasional and casual.

376. Chaerophyllum L.

1192. **C. temulum** L. (Schulz, 'Beiträge,' I, p. 62; Herm. Müller, 'Fertilisation,' p. 279, 'Weit. Beob.,' I, p. 310; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 155.)—Schulz describes this white-flowered species as andromonoecious, with markedly protandrous hermaphrodite flowers. In most umbels there are marginal hermaphrodite flowers, and also a central one; the rest are male. The number of the latter increases in umbels of higher order: tertiary ones are usually completely male, and sometimes even the inner umbellules of secondary ones may be so.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *L.* (H. M.); 2. Obrium brunneum *F.*, nect-lkg. (Budd.); 3. Pachyta octomaculata *F.* (Budd., Borgstette). (*b*) *Dermestidae*: 4. Anthrenus pimpinellae *F.* (H. M.); 5. A. scrophulariae *L.* (H. M.). (*c*) *Mordellidae*: 6. Anaspis rufilabris *Gyll.*, nect-lkg. (H. M.). (*d*) *Nitidulidae*: 7. Epuraea aestiva *L.*, nect-lkg. (H. M.); 8. Meligethes aeneus *F.*, do. **B. Diptera.** (*a*) *Muscidae*: 9. Gymnosoma rotundata *L.* (H.M.). (*b*) *Stratiomyidae*: 10. Chrysomyia formosa *Scop.* (H. M.). (*c*) *Syrphidae*: 11. Bacha elongata *F.* (H. M.); 12. Cheilosia scutellata *Fall.* (H. M.); 13. C. sp., po-dvg. (Budd.); 14. Chrysogaster coemeteriorum *L.* (H. M.); 15. Eristalis nemorum *L.* (H. M.); 16. Helophilus floreus *L.*, skg. and po-dvg. (H. M., Budd.); 17. Melanostoma mellina *L.* (H. M.); 18. Melithreptus scriptus *L.* (H. M.); 19. Syritta pipiens *L.* (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 20. Andrena parvula *K.* ♀, skg. (H. M.); 21. Apis mellifica *L.* ☿, po-cltg. (H. M.); 22. Prosopis armillata *Nyl.* ♀ (H. M.); 23. P. communis *Nyl.* ♂ (H. M.). (*b*) *Formicidae*: 24. Several sp. (*c*) *Ichneumonidae*: 25. Numerous sp. (*d*) *Sphegidae*: 26. Crabro dives *H-Sch.* ♂, nect-lkg. (H. M.); 27. Oxybelus uniglumis *L.* freq. (H. M.); 28. Pompilus pectinipes *v. d. L.* ♂ (H. M.); 29. P. spissus *Schjödte* (H. M.). (*e*) *Tenthredinidae*: 30. Hylotoma caerulescens, *F.*, nect-lkg. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth (Föhr), 2 Syrphids and a Pseudoneuropterid. Alfken (Bremen).—**A. Diptera.** *Syrphidae*: 1. Chrysogaster coemeteriorum *L.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Andrena shawella *K.* ♂. (*b*) *Ichneumonidae*: 3. Campoplex oxyacanthae *Boie.* Schenck (Nassau).—**Hymenoptera.** (*a*) *Apidae*: 1. Andrena proxima *K.* ♀, very common. (*b*) *Sphegidae*: 2. Diodontus minutus *F.*; 3. Tachysphex nitidus *Spin.* (*c*) *Sapygidae*: 4. Sapyga clavicornis *L.* F. F. Kohl (Tyrol), the true wasp Leionotus dufourianus *Sauss.*, and the fossorial wasp Crabro cribrarius *L.*, ♀ and ♂. MacLeod (Flanders), 6 Syrphids, a Stratiomyid, a gnat, 7 short-tongued Hymenoptera, and 6 beetles (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 287).

1193. **C. bulbosum** L.—Kirchner ('Flora v. Stuttgart,' p. 396) describes this species as andromonoecious, with a similar distribution of sexes to that of C. temulum. The quaternary umbels, which develop late, are almost always completely male.

Visitors.—Loew (Berlin Botanic Garden) observed the bee Prosopis armillata *Nyl.* ♀, skg.

1194. **C. aureum** L.—According to Schulz ('Beiträge,' II, p. 191), this species is also andromonoecious, with protandrous hermaphrodite flowers.

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus scrophulariae *L.*, nect-lkg. (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.* **B. Diptera.** (*a*) *Bibionidae*: 3. Bibio hortulanus *L.* ♀, skg. (*b*) *Muscidae*: 4. Graphomyia maculata *Scop.* (*c*) *Stratiomyidae*: 5. Stratiomys longicornis *Scop.* (*d*) *Syrphidae*: 6. Eristalis nemorum *L.*, skg.; 7. Helophilus floreus *L.*; 8. Melanostoma mellina *L.*, skg.; 9. Platycheirus scutatus *Mg.*, do.; 10. Syritta pipiens *L.*, do.; 11. Syrphus ribesii *L.*, do.

The following were recorded by the observers, and for the localities stated.—

MacLeod (Pyrenees), 7 short-tongued Hymenoptera, 5 beetles, 6 Syrphids, and 17 other Diptera (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 415–16). von Dalla Torre (Innsbruck Botanic Garden), the bee Prosopis annulata *L.* ♀ and ♂.

1195. **C. aromaticum** L.—Schulz ('Beiträge') describes this species again as andromonoecious, with protandrous hermaphrodite flowers. According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 295), each umbellule contains a central and 3–5 marginal hermaphrodite flowers, the intermediate space being occupied by about 20 pseudo-hermaphrodite male ones. The hermaphrodite flowers develop earlier than the male ones, their anthers having fallen off and their stigmas matured before dehiscence takes place in the latter. The stigmas come into the line of fall of the pollen of the male flowers, and are thus geitonogamously crossed. (*Cf.* Fig. 155, p. 463, and Vol. I, pp. 41–2.)

1196. **C. hirsutum** L.—Schulz ('Beiträge,' II, p. 191) describes this species also as andromonoecious, with protandrous hermaphrodite flowers.

Visitors.—Herm. Müller observed the following ('Fertilisation,' pp. 278–9).—

A. Coleoptera. (*a*) *Elateridae*: 1. Agriotes gallicus *Lac.* (*b*) *Oedemeridae*: 2. Oedemera flavescens *L.* **B. Diptera.** (*a*) *Syrphidae*: 3. Eristalis pertinax *Scop.* **C. Hymenoptera.** (*a*) *Apidae*: 4. Sphecodes ephippius *L.* (*b*) *Chrysididae*: 5. Chrysis ignita *L.* (*c*) *Evaniidae*: 6. Foenus affectator *F.* (*d*) *Sphegidae*: 7. Crabro subterraneus *F.* ♂; 8. Pompilus pectinipes *v. d. L.* (*e*) *Tenthredinidae*: 9. Athalia rosae *L.*; 10. Hylotoma enodis *L.*, in large numbers; 11. H. segmentaria *Pz.*; 12. Allantus arcuatus *Forst.*; 13. A. rossii *Pz.*; 14. Tenthredo sp.

Loew saw the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella septempunctata *L.*, nect-lkg. (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.* (*c*) *Telephoridae*: 3. Malachius bipustulatus *L.*, nect-lkg. **B. Diptera.** (*a*) *Bibionidae*: 4. Bibio hortulanus *L.* ♂, skg. (*b*) *Muscidae*: 5. Graphomyia maculata *Scop.*; 6. Onesia floralis *R.-D.* (*c*) *Syrphidae*: 7. Eristalis sepulcralis *L.*, skg. **C. Hymenoptera.** *Apidae*: 8. Andrena tibialis *K.* ♂, skg.; 9. Apis mellifica *L.*, skg. and po-cltg.

1197. **C. villarsii** Koch (=C. hirsutus *Vill.*).—According to Schulz ('Beiträge,' II, pp. 89–90, 191), this species is andromonoecious, with markedly protandrous hermaphrodite flowers. The primary umbels usually bear marginal hermaphrodite and central male flowers; secondary ones are chiefly male.

Visitors.—Herm. Müller observed 9 beetles, 23 Diptera, 4 Hymenoptera, 3 Lepidoptera, and a Neuropterid in the Alps ('Alpenblumen,' p. 123).

Loew, also for the Alps (Pontresina) records the following ('Beiträge,' p. 55).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Callidium violaceum *L.*; 2. Strangalia melanura *L.*; 3. Tetropium luridum *L.* (*b*) *Telephoridae*: 4. Dasytes alpigradus *Kiesw.*; 5. Rhagonycha nigripes *Redt.*; 6. R. denticollis *Schumm.* **B. Diptera.** (*a*) *Bombyliidae*: 7. Anthrax paniscus *Rossi.* (*b*) *Syrphidae*: 8. Chrysotoxum vernale *Lw.*; 9. Eristalis tenax *L.*; 10. Volucella bombylans *K.* (*c*) *Tabanidae*: 11. Tabanus borealis *F.* ♂. **C. Hymenoptera.** *Tenthredinidae*: 12. Tenthredo sp. **D. Lepidoptera.** (*a*) *Geometridae*: 13. Odezia atrata *L.* (*b*) *Noctuidae*: 14. Undetermined sp.

377. Echinophora Tourn.

1198. **E. spinosa** L. (Kirchner, 'D. Blüten d. Umbelliferen.')—This white-flowered species, which resembles a thistle in habit, is common on the Lido at Venice. The umbels are flat or somewhat convex; each umbellule includes about twelve flowers, but marginal ones have more and central ones fewer. Only the middle flower of an umbellule is hermaphrodite, all the others being male, with no styles and merely a vestigial ovary, on which is a translucent annular disk, that secretes nectar. Before the anthers dehisce, the filaments of all the flowers are curved inwards, but they afterwards diverge, and their anthers open. The white petals are deeply bilobed, and there is an inwardly directed appendage in the middle of the incision. The petals of the inner flowers of the whole umbel, and of each umbellule, are very small; those of the marginal flowers (especially at the periphery of each umbel) are larger and spreading. The two stigmas of a central flower have become receptive before any of the stamens of the same umbellule have erected themselves: the filaments of the male flowers diverge in centripetal order. The styles and stigmas of an hermaphrodite flower persist till all the anthers of the same umbellule have withered. This early development and long persistence of the stigmas undoubtedly secure the crossing of the relatively few hermaphrodite flowers, in which automatic self-pollination is excluded by the relative positions of the reproductive organs. It would also be superfluous, as the flowers are visited by many insects.

Visitors.—Flies, hover-flies, bees, and several Lepidoptera (Lycaena, Zygaena, and a micro-Lepidopterid) have been observed.

378. **Myrrhis** L.

1199. **M. odorata** Scop. (Herm. Müller, 'Fertilisation,' p. 278, 'Weit. Beob.,' I, p. 311; Schulz, 'Beiträge,' II, p. 191.)—Schulz describes this species as andromonecious, with protandrous hermaphrodite flowers. Herm. Müller says that the last flowers which appear are purely male, their small petals falling off without ovary, styles, or stigmas having developed. These flowers consequently provide pollen for fertilizing the youngest hermaphrodite ones.

Visitors.—Herm. Müller (H. M.) at Lippstadt, and Borgstette (Borg.) at Tecklenburg, observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Grammoptera ruficornis *F.*, in large numbers (H. M.). (*b*) *Chrysomelidae*: 2. Galeruca calmariensis *L.* (Borg.). (*c*) *Dermestidae*: 3. Anthrenus scrophulariae *L.*, in very large numbers, nect-lkg. (H. M.). (*d*) *Mordellidae*: 4. Anaspis frontalis *L.*, nect-lkg. (H. M.). 5. Mordellistena pumila *Cyll.*, occasional, nect-lkg. (H. M.). (*e*) *Nitidulidae*: 6. Epuraea sp., freq. (H. M.); 7. Meligethes aeneus *F.*, occasional, nect-lkg. (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 8. Bombylius maior *L.* (Borg.). (*b*) *Empidae*: 9. Empis punctata *F.*, skg. (H. M.); 10. E. stercorea *L.*, freq., skg. (H. M.); 11. E. tessellata *F.* (Borg.); 12. E. vernalis *Mg.* ♂ (H. M.); 13. Platypalpus candicans *Fall.* (H. M.); 14. Rhamphomyia umbripennis *Mg.* ♀ (H. M.). (*c*) *Muscidae*: 15. Anthomyia aterrima *Mg.* and other sps. (H. M.); 16. Calobata cothurnata *Pz.*, in large numbers (H. M.); 17. Chlorops hypostigma *Mg.*, freq. (H. M.). 18. Coenosia intermedia *Fall.* (H. M.); 19. Cordylura pubera *L.* (H. M.); 20. Dryomyza flaveola *F.* (H. M.); 21. Nemopoda cylindrica *F.* (H. M.); 22. N. stercoraria *R.-D.* (H. M.); 23. Piophila casei *L.* (H. M.); 24. Psila fimetaria *L.*, in large numbers (H. M.); 25. Scatophaga lutaria *F.* (H. M.); 26. Sepsis sps., in large numbers (H. M.). (*d*) *Syrphidae*: 27. Xylota femorata *L.* (Borg.). (*e*) *Tipulidae*: 28. Species of Tipula (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 29. Halictus maculatus *Sm.* (Borg.). (*b*) *Formicidae*: 30. Lasius brunneus *Ltr.* ☿ and other species of ants (H. M.). (*c*) *Ichneumonidae*: 31. Several sps. (Borg.). (*d*) *Tenthredinidae*: 32. Allantus temulus *Scop.*, nect-lkg. (H. M.); 33. Athalia rosae *L.* (H. M.); 34. Rhogogastera viridis *L.*, nect-skg. (H. M.); 35. Tenthredo flavicornis *F.*, do. (H. M.).

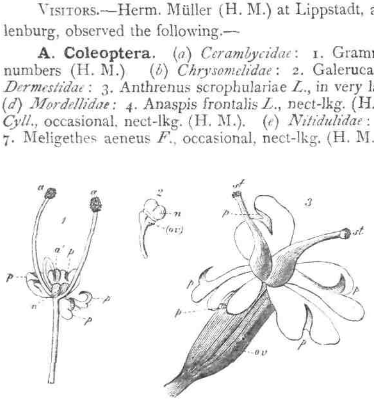


Fig. 167. *Myrrhis odorata, Scop.* (after Herm. Müller). (1) Male flower, as it appears at the end of anthesis. (2) Ditto, after it has faded. (3) Hermaphrodite flower in the last (purely female) stage. *a*, dehisced anthers; *a'*, undehisced anther; *n*, nectary; *ov*, ovary; *p*, petal; *st*, stigma.

The following were recorded by the observers, and for the localities stated.—

MacLeod (Pyrenees), 4 short-tongued Hymenoptera, a beetle, and 5 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 417). Scott-Elliot (Dumfriesshire), a saw-fly, 2 Empids and 6 Muscids ('Flora of Dumfriesshire,' p. 80). Loew (Berlin Botanic Garden).—**A. Coleoptera.** *Scarabaeidae*: 1. Cetonia aurata *L.*, dvg. the flowers. **B. Diptera.** (*a*) *Muscidae*: 2. Chloria demandata *F.*; 3. Lucilia caesar *L.*; 4. Scatophaga merdaria *F.* (*b*) *Syrphidae*: 5. Eristalis nemorum *L.*, skg.

379. Molopospermum Koch.

1200. M. Peloponnesiacum Koch.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus scrophulariae *L.*, nect-lkg. (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.*, dvg. the flowers. (*c*) *Telephoridae*: 3. Telephorus fuscus *L.*, nect-lkg. **B. Diptera.** (*a*) *Bibionidae*: 4. Bibio hortulanus *L.*, skg. (*b*) *Muscidae*: 5. Echinomyia fera *L.*, skg.; 6. Scatophaga merdaria *F.* (*c*) *Stratiomyidae*: 7. Stratiomys longicornis *Scop.* (*d*) *Syrphidae*: 8. Eristalis nemorum *L.*, skg. **C. Hymenoptera.** (*a*) *Apidae*: 9. Andrena tibialis *K.* ♀, skg. and po-cltg.; 10. Apis mellifica *L.* ☿, ditto. (*b*) *Tenthredinidae*: 11. Hylotoma rosae *L.* ♂.

380. Prangos Lindl.

1201. P. ferulacea Lindl.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella bipunctata *L.*, nect-lkg. (*b*) *Curculionidae*: 2. Ceutorhynchidius floralis *Payk.* (*c*) *Dermestidae*: 3. Anthrenus scrophulariae *L.*, nect-lkg. **B. Diptera.** (*a*) *Muscidae*: 4. Graphomyia maculata *Scop.*; 5. Lucilia caesar *L.* (*b*) *Syrphidae*: 6. Eristalis arbustorum *L.*; 7. Helophilus floreus *L.* **C. Hymenoptera.** (*a*) *Formicidae*: 8. Lasius niger *L.*, nect-lkg. (*b*) *Ichneumonidae*: 9. Campoplex sp.

XLIX. ORDER *ARALIACEAE* JUSS.

381. Hedera Tourn.

Flowers greenish in colour; protandrous or homogamous; with exposed nectar, secreted by a disk surrounding the styles.

1202. H. Helix L. (Delpino, 'Altri appar. dicog. recent. oss.,' p. 52; Herm. Müller, 'Weit. Beob.,' I, pp. 301–2; Knuth, 'Blütenbiol. Herbstbeob.'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, vi, 1894, pp. 255–6; Kirchner, 'Flora v. Stuttgart,' p. 398; Macchiati, Bot. Centralbl., Cassel, xxi, 1885, p. 7; Wittrock, op. cit., xxvi, 1886, p. 124.)—In Schleswig-Holstein the ivy is one of the latest plants to blossom, and (in 1890) I observed the first buds open on Nov. 1, from which date flowering went on until mid-December. About twenty green flowers, with stalks 1–1·5 cm. long, are aggregated into a hemispherical umbel, and the faint almost putrefactive odour attracts various minute and larger flies, as well as Hymenoptera. The individual flowers are protandrous. There are five (rarely six) recurved petals, surrounding a nectar-secreting yellowish-green disk. In the middle of this rises the short (scarcely 1 mm.) style with its stigma. The five (rarely six) inwardly inclined stamens are situated at the margin of the disk; the filaments are 2–3 mm. long. The anthers are bright yellow in colour, turning to a brownish-yellow and quickly dropping off after dehiscence. The stigma is now mature, and the disk secretes nectar more actively, thus compensating for the diminution in conspicuousness resulting from the loss of the anthers. The under-sides of insects visiting flowers in the first (male) stage get dusted with pollen, which is transferred to the stigmas of those in the second (female) stage.

Delpino also describes the flowers as protandrous, and he observed flies effecting

pollination. Hermann Müller and Kirchner, on the contrary, found them to be homogamous. The insect visitors of these flowers, however, effect cross-pollination, for they alight upon the central stigma, and do not touch the radiating stamens till afterwards. Hermann Müller and Kirchner add that nectar is secreted so abundantly that, if not removed by insects, it covers the nectary with a white sugary crust after the flower has faded. Wittrock calls attention to the fact that the ivy but rarely blooms in Central Sweden, the most northerly point for this being in Södermanland (58° 57′ N. lat.). The same writer mentions that the ivy flowering every October in a Stockholm greenhouse never produces fruit, probably owing to the absence of the insects necessary for pollination. Automatic self-pollination would therefore seem to be ineffective.

VISITORS.—Burkill and Willis observed the following near Cambridge ('Fls. and Insects in Gt. Britain.').—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia, 2 sp.; 2. Aricia lucorum *Fall.*; 3. Calliphora erythrocephala *Mg.*, very common, skg.; 4. Chloropisca ornata *Mg.*; 5. Hydrellia griseola *Fall.*; 6. Limnophora sp.; 7. Lucilia sp., skg.; 8. Onesia sepulcralis *Mg.*, skg.; 9. Phytomyza sp.; 10. Aricia lardaria *F.*; 11. Pollenia rudis *F.*, freq., skg.; 12. Drosophila graminum *Fall.*; 13. Scatophaga stercoraria *L.*, skg.; 14. Siphona geniculata *Deg.*, do.; 15. Trichophthicus cunctans *Mg.* (*b*) *Syrphidae*: 16. Eristalis tenax *L.*, freq., skg. (*c*) *Mycetophilidae*: 17. Bolitophila fusca *Mg.*; 18. Metriocnemus sp.; 19. Orthocladius sp.; 20. Sciara sp. **B. Hymenoptera.** (*a*) *Ichneumonidae*: 21. Five undetermined species. (*b*) *Vespidae*: 22. Vespa vulgaris *L.*, freq., skg. **C. Lepidoptera.** *Tortricidae*: Tortrix sp.

The following were recorded by the observers, and for the localities stated.—

Knuth, the wasp Vespa vulgaris *L.*, the Muscid Aricia lardaria *F.*, and the earwig Forficula auricularia. Herm. Müller, 3 Muscids—1. Calliphora erythrocephala *Mg.*; 2. Echinomyia fera *L.*, freq.; 3. Lucilia cornicina *F.*, do. Plateau (Belgium), the wasp Vespa germanica *L.*, in countless numbers; 2 hover-flies (Eristalis, Helophilus); and a Muscid (Calliphora vomitoria *L.*, freq.). Schletterer (Pola), the Scoliid Scolia hirta *Schr.* (Oct. 10), and (also in October) 3 true wasps—1. Eumenes mediterranea *Krchb.*; 2. Polistes gallica *L.*; 3. Vespa germanica *F.*

L. ORDER *CORNACEAE* DC.

382. Cornus L.

Flowers homogamous; with exposed nectar, secreted by a ring surrounding the style.

1203. C. sanguinea L. (Herm. Müller, 'Fertilisation,' pp. 287–8, 'Weit. Beob.,' I, p. 301; Kirchner, 'Flora v. Stuttgart,' p. 399; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Beob. a. d. Ins. Rügen.')—Hermann Müller says that in this species the stamens and stigmas develop simultaneously. The anthers are introrse, and at the same level as the stigma, though some distance from it. The larger insects that alight on the inflorescence, or on a single flower, will therefore, when licking the nectary, usually touch an anther or two with one side of their heads, and the stigma with the other. Should they creep further on the same inflorescence, or visit another, cross-pollination will be favoured. Smaller flies and beetles, on the contrary, owing to their erratic movements, will sometimes effect cross- sometimes

self-pollination. Hermann Müller states that automatic geitonogamy may now and then take place, for some of the stigmas are touched by the anthers of the diverging stamens of neighbouring flowers. (*Cf.* 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 325–6.) The flowers possess the odour of trimethylamide. Warnstorf describes the pollen-grains, when examined in water, as large, rounded, opaque, with granular protoplasm, 63 to 75 μ in diameter.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel), several skg. or po-dvg. hover-flies (1. Eristalis tenax *L.*; 2. E. arbustorum *L.*; 3. Syrphus balteatus *Deg.*; 4. Volucella pellucens *L.*) and Muscids (1. Lucilia caesar *L.*; 2. L. cornicina *F.*): (Rügen), the butterfly Argynnis paphia *L.*, skg. for a short time. Krieger (Leipzig), the true wasp Odynerus spinipes *L.*, and the bee Andrena labiata *Schenck* (=A. schencki *Mor.*). Schmiedeknecht (Nassau), the bee Andrena carbonaria *L.* von Dalla Torre (Tyrol), the bee Andrena albicans *Müll.* ♀. MacLeod (Flanders), an Empis, and the beetle Meligethes (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 256).

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Clytus arietis *L.* (Budd.); 2. Grammoptera tabacicolor *Deg.* (H. M.); 3. Leptura livida *F.* (H. M.); 4. Pachyta octomaculata *F.* (Budd.); 5. Strangalia armata *Hbst.* (H. M., Budd.); 6. S. atra *Laich.* (H. M.); 7. S. attenuata *L.* (H. M.). (*b*) *Curculionidae*: 8. Otiorhynchus picipes *F.* (H. M.). (*c*) *Dermestidae*: 9. Byturus fumatus *F.* (H. M.) (*d*) *Elateridae*: 10. Athous niger *L.* (H. M.); 11. Dolopius marginatus *L.* (H. M.). (*e*) *Telephoridae*: 12. Telephorus pellucidus *F.* (H. M.). (*f*) *Nitidulidae*: 13. Meligethes (H. M.); 14. Thalycra sericea *Sturm.* (H. M.). **B. Diptera.** (*a*) *Empidae*: 15. Empis livida *L.* (H. M.). (*b*) (?). 16. A tiny gnat in very large numbers (H. M.). (*c*) *Syrphidae*: 17. Eristalis arbustorum *L.*, po-cltg. (H. M.); 18. E. nemorum *L.*, po-cltg. (H. M.); 19. Volucella pellucens *L.* (Budd.). **C. Hymenoptera.** *Sphegidae*: 20. Pompilus sp. (H. M.). All these visitors were licking the fleshy disk.

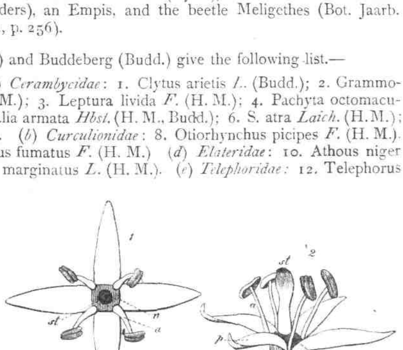


FIG. 168. *Cornus sanguinea, L.* (after Herm. Müller). (1) Flower seen from above. (2) Do., from the side. *a*, stamen; *n*, nectary; *ov*, ovary; *p*, petal; *s*, sepal; *st*, stigma.

1204. C. Mas L. (Sprengel, 'Entd. Geh.,' p. 85; Schulz, 'Beiträge,' II, p. 191.) —Schulz says that the yellow flowers of this species are hermaphrodite and homogamous; but they have also been described as dioecious, or polygamous. The mechanism of the hermaphrodite flowers agrees with that of C. sanguinea. According to Kerner (loc. cit.), geitonogamy may also take place as in that species. Warnstorf describes the pollen-grains as pale-yellow in colour, ellipsoidal to ovoid, almost smooth, 37 μ long and 23–25 μ broad.

1205. C. florida L.—Kerner states that this species displays the same kind of geitonogamy as C. Mas.

1206. C. suecica L. (Knuth, 'Bloemenbiol. Bijdragen.')—I had the opportunity of examining the flower mechanism of this species in the Dravitholz, between Tondern and Lügumkloster (Central Schleswig), at the beginning of July, 1891. The four yellowish bracts, streaked with reddish veins, play the part of petals, so that a pseudo-flower with a diameter of nearly 2 cm. is formed. Each bract is 1 cm. long; one pair of opposite bracts are somewhat broader than the others, i. e. 8 mm. as compared with 6. From the middle of this pseudo-flower spring about twenty truly hermaphrodite flowers, arranged in an umbel. They are red in colour, only 2 mm. long, and borne upon peduncles of the same length. Sepals and petals are recurved. The style of each flower, with its stigma, is 1 mm. high, while the four diverging stamens are 2 mm. in length. An insect alighting on the umbel must therefore first touch the stigmas, and then the anthers, so that cross-pollination is effected when a visit is made to a second flower.

I could not decide whether the flowers were protandrous or homogamous with persistent stigmas, for it was only towards the end of anthesis that I was able to examine them; most of the anthers had dropped off, while the stigmas were still receptive.

Failing insect-visits, automatic geitonogamy is possible by the spreading of the stamens so as to touch the neighbouring flowers.

Visitors.—I observed a few hover-flies—Eristalis arbustorum *L.*, and Helophilus pendulus *L.*, po-dvg.

LI. ORDER *CAPRIFOLIACEAE* JUSS.

Literature.—Hermann Müller, 'Fertilisation,' pp. 289–99; Knuth, 'Grundriss d. Blütenbiol.,' pp. 61–2.

As Hermann Müller has remarked, the members of this order are extremely variable in regard to their flower mechanisms. Lonicera Caprifolium possesses a corolla-tube as much as 30 mm. long, and its nectar is therefore only available to hawk-moths with the most elongated proboscis; L. Periclymenum, with a corolla-tube about 20 mm. in length, gives access to long-tongued bees as well as to hawk-moths; L. caerulea is a humble-bee flower; L. nigra is a bee-flower; while the nectar of L. tatarica and L. Xylosteum (corolla-tube only 3–7 mm. long) is accessible to bees and also to certain flies; Symphoricarpos is regarded by Hermann Müller as a wasp-flower (I observed chiefly bees, but also hover-flies as visitors), and Lonicera alpigena is similar; the funnel-shaped corolla of Linnaea also allows insects with a moderately short proboscis to reach the nectar; Viburnum possesses fully exposed nectar, and is therefore pollinated by short-tongued insects (flies and beetles), which also visit to some extent the nectarless species of Sambucus; Adoxa, finally, with its perfectly flat exposed layer of nectar, attracts minute insects of various orders (flies, Neuroptera, beetles). Automatic self-pollination is chiefly rendered possible in species which receive the smallest number of insect-visits; cross-

pollination is ensured when such visits take place. Our most important native types of the order are therefore distributed as follows among the flower classes.—

Po, Sambucus;

E, Viburnum, Adoxa;

C, Symphoricarpos, Linnaea, Lonicera alpigena, L. tatarica, L. Xylosteum;

H, Lonicera caerulea, L. nigra;

Lm, Lonicera Periclymenum, L. Caprifolium.

383. Adoxa L.

Flowers inconspicuous, greenish; homogamous or protogynous; with exposed nectar, secreted by a fleshy ring at the base of the stamens.

1207. A. Moschatellina L. (Herm. Müller, 'Fertilisation,' pp. 289–90; Ricca, Atti Soc. ital. sc. nat., Milano, xiii, 1870; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 389; Knuth, 'Bloemenbiol. Bijdragen'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 334–5; Kirchner, 'Flora v. Stuttgart,' p. 668.)—The flowers of this species

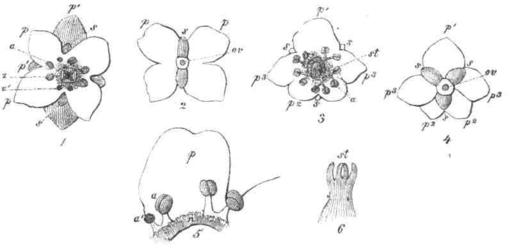


FIG. 169. *Adoxa Moschatellina, L.* (after Herm. Müller). (1) Terminal flower, seen from above ($\times 3\frac{1}{2}$). (2) Ditto, seen from below. (3) Lateral flower, opened and spread out, the style pressed downwards; seen from the front. (4) Ditto, seen from behind. (5) Part of a flower with two (divided) stamens ($\times 7$). (6) Style of a terminal flower, seen from the side. *a*, immature half-anther; *a′*, ditto, mature; *n*, nectary; *ov*, ovary; *p*, petal of the terminal flower; p^1, upper petal of a lateral flower; p^2, lower petal of ditto; $p^{\prime\prime}$, lateral petal of ditto; *s*, sepal; *st*, stigma.

are arranged in a cuboidal head, and exhale a faint musky odour. According to Hermann Müller, the stamens of the terminal tetramerous flower are directed upwards, while those of the four lateral pentamerous flowers are directed outwards. The anthers are at the same level as the stigmas, which develop simultaneously. When nectar-licking or pollen-devouring insects creep over the blossoms, they sometimes touch the anthers and sometimes the stigmas with their feet or proboscis; and chiefly effect cross-pollination. Automatic self-pollination is possible in the lateral flowers, by the fall of pollen on the edges of the stigmas; in the terminal ones this only takes place when the plant is bent over by the wind. Kerner describes the flowers as protogynous, and says that the anthers are at first remote from the stigmas; the filaments later on inclining inwards, so as to bring about self-pollination.

Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) says that at Ruppin the flowers are slightly protogynous to homogamous: the terminal flower (with eight or rarely ten stamens) opens first, then the pairs of opposite lateral flowers in succession. Sometimes the terminal and one or two lateral flowers are degenerate. The 4–7 stigmatic branches, and also the anthers, persist for several days; the latter are at a lower level than the stigmas, so that autogamy is scarcely possible. The pollen-grains are bright yellow in colour, ovoid, slightly tuberculated, very variable in size, up to 37 μ long and 18 μ broad.

Visitors.—Warnstorf observed small beetles, and Herm. Müller gives the following list.—

A. Coleoptera. *Curculionidae*: 1. Apion columbinum *Germ.*, nect-lkg. **B. Diptera.** (*a*) *Cecidomyidae*: 2. Various sps., nect-lkg. (*b*) *Muscidae*: 3. Borborus niger *Mg.*, nect-lkg. (*c*) *Mycetophilidae*: 4. Various species, from 1½ to 4 mm. long. (*d*) *Simuliidae*: 5. Simulia sp. **C. Hymenoptera.** (*a*) *Ichneumonidae*: 6. Pezomachus *Grav.*, 2 sps. (*b*) *Pteromalidae*: 7. Eulophus ♂; 8. Seven other species.

Burkill observed the following on the Yorkshire coast ('Fertlsn. of Spring Fls.').—

A. Coleoptera. *Curculionidae*: 1. Apion apricans *Hbst.*, skg. **B. Diptera.** (*a*) *Muscidae*: 2. Scatophaga stercoraria *L.*; 3. Sepsis nigripes *Mg.* (*b*) *Mycetophilidae*: 4. Exechia sp.; 5. Sciara sp. and 3 other species. (*c*) *Rhyphidae*: 6. Rhyphus sp. (*d*) *Syrphidae*: 7. Melanostoma quadrimaculata *Verral.* **C. Hymenoptera.** *Ichneumonidae*: 8. Pezomachus sp. and one other small Ichneumon. **D. Thysanoptera.** 9. Thrips sp., all skg.

MacLeod saw a Neuropterid, a fly, and a beetle in Flanders (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 389).

384. **Ebulum** Garcke.

Flowers reddish-white in colour, odorous, arranged in umbellate panicles; with exposed nectar, secreted on the top of the ovary.

1208. E. humile Garcke (=Sambucus Ebulus *L.*).—According to Bonnier (*vide* Herm. Müller, 'Alpenblumen,' p. 392), the white flowers of this species, which are reddish externally, secrete exposed nectar. Kirchner ('Flora v. Stuttgart,' p. 670) states that the diameter of the corolla is 8 mm., and that the stamens project almost vertically from it.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Switzerland), Apis, 2 sp. of Bombus, and a Volucella. Borgstette (Herm. Müller, 'Weit. Beob.,' III, p. 76) (Central Germany), 2 flies (Leptis vitripennis *Mg.*, and Aricia *sp.*). von Dalla Torre and Schletterer (Tyrol), 2 bees—Nomada ferruginata *K.* ♀, and Sphecodes gibbus *L.* ♂. MacLeod (Pyrenees), 4 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 346). Scott-Elliot (Dumfriesshire), a humble-bee, several flies and Lepidoptera ('Flora of Dumfriesshire,' p. 81). Loew (Berlin Botanic Garden), the Muscid Lucilia caesar *L.*, and 2 Syrphids—Eristalis nemorum *L.*, and Helophilus floreus *L.*

385. Sambucus Tourn.

Flowers whitish in colour, often odorous; homogamous or protogynous; arranged in large cymes.

1209. S. nigra L. (Herm. Müller, 'Fertilisation,' p. 290, 'Weit. Beob.,' III, p. 76; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 369; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 80, 156; Kirchner, 'Flora v. Stuttgart,' p. 669; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The homogamous yellowish-white flowers of this species are nectarless, but strongly odorous. They are crowded together into large flat inflorescences, arranged in tiers, so as to be very conspicuous. In spite of this, insect visitors are but few; perhaps the pungent odour is repugnant to many of them, or perhaps the booty is too small. The stamens diverge widely, while the stigmas are sessile on the ovary in the base of the flower. Insects creeping over the inflorescences, while devouring or collecting pollen, effect cross- and self-pollination with equal facility; the latter also readily takes place automatically, for the stigmas lie in the line of fall of the pollen.

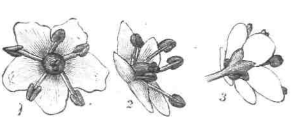


FIG. 170. *Sambucus nigra*, *L.* (after Herm. Müller). (1) Flower seen from the front. (2) Ditto, seen obliquely from the front. (3) Ditto, seen obliquely from behind. (× 3½.)

Warnstorf states that the stamens spread outwards in the course of anthesis, and may possibly effect geitonogamy. Self-pollination is also rendered difficult by extrorse dehiscence of the anthers. The pollen-grains are pale-yellow in colour, small, ellipsoidal, densely tuberculated, up to 31 μ long and 15–16 μ broad.

According to Kirchner, there are nectar-secreting glands on the petioles; and these attract ants, which serve to protect the plant against animals creeping up from the ground.

VISITORS.—Herm. Müller observed a beetle in the Alps, and the following in Central and South Germany.—

A. Coleoptera. *Scarabaeidae*: all gnawing the petals and other parts of the flowers: 1. Cetonia aurata *L.*; 2. Gnorimus nobilis *L.*; 3. Oxythyrea stictica *L.*; 4. Phyllopertha horticola *L.*; 5. Trichius fasciatus *L.* **B. Diptera.** (*a*) *Stratiomyidae*: 6. Sargus cuprarius *L.*, po-dvg. (*b*) *Syrphidae*: all po-dvg.: 7. Eristalis arbustorum *L.*; 8. E. horticola *Deg.*; 9. E. nemorum *L.*; 10. E. tenax *L.*; 11. Volucella pellucens *L.* **C. Hymenoptera.** (*a*) *Tenthredinidae*: 12. Allantus nothus *Klg.*

The following were recorded by the observers, and for the localities stated.—

Knuth (Föhr), 2 po-dvg. hover-flies—Eristalis tenax *L.*, and Syrphus ribesii *L.*; (Helgoland), the Muscid Lucilia caesar *L.* creeping over the umbels, and effecting geitonogamy. F. F. Kohl (Tyrol), the ruby-wasp Ellampus aeneus *F.* Rössler (Wiesbaden), the moth Botys sambucalis *Schiff.* MacLeod (Pyrenees), the beetle Cetonia aurata *L.* (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 346).

1210. S. racemosa L. (Kirchner, 'Flora v. Stuttgart,' p. 670; Schulz, 'Beiträge,' II, pp. 94–5; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 200, 326.)—Kirchner describes the flowers of this species as being protogynous, with persistent

stigmas, in Wurtemberg; but in the South Tyrol, according to Schulz, there is variation between protogyny, homogamy, and slight protandry. Kerner says that their odour suggests herring-brine (trimethylamide), while Kirchner describes it as meal-like. The latter also states that, after the flowers have opened, the tips of the petals sometimes bend right back, and the stamens diverge so much as to be almost in one plane; their anthers, however, are still unripe, while the three short stigmas are fully mature. The tips of the petals then grow to some extent, and assume a yellowish colour; the anthers dehisce downwards and outwards, the stigmas remaining receptive. All the flowers of an inflorescence, at a given time, are in about the same stage of anthesis. As the inflorescences are of more inconspicuous greenish colour in the first (female) than in the second (hermaphrodite) stage, flowers in the latter condition are usually first visited by insects, which afterwards transfer the pollen to those in the female stage. In the second stage automatic self- and cross-pollination are both possible, for the numerous flowers are turned in all directions. Kerner describes geitonogamy as taking place in the later stages of anthesis by elongation and bending of the filaments, so that pollen is applied to the stigmas of neighbouring flowers.

VISITORS.—Redtenbacher (Vienna) noticed 2 Cerambycid beetles—Leptura virens *L.*, and Strangalia quadrifasciata *L.*

1211. **S. australis** Cham. et Schlecht.—K. Müller describes this species as gynodioecious (Ber. D. bot. Ges., Berlin, ii, 1884).

386. Viburnum L.

Flowers white in colour, possessing an odour of amide; arranged in umbellate cymes; homogamous; with exposed to half-concealed nectar, secreted in a flat layer on the upper surface of the ovary, immediately below the stigmas, in the base of the flower.

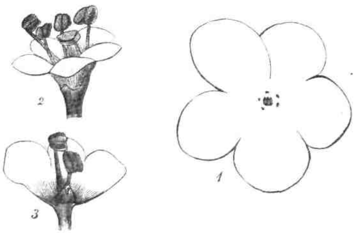


FIG. 171. *Viburnum Opulus, L.* (after Herm. Müller). (1) Marginal flower seen from above, showing the vestiges of anthers and stigma (× 2½). (2) Fertile flower, soon after opening, seen obliquely from above (× 4⅝). (3) Ditto, after removal of the anterior petals and stamens (× 4⅝).

1212. **V. Opulus** L. (Sprengel, 'Entd. Geh.,' p. 159; Herm. Müller, 'Fertilisation,' pp. 291–2, 'Weit. Beob.,' III, pp. 75–6; Knuth, 'Bloemenbiol. Bijdragen.')—Sprengel clearly explained how the large marginal neuter flowers serve to render the whole inflorescence more conspicuous in this species.

Hermann Müller describes the hermaphrodite flowers as homogamous. The diverging stamens project from them, and their anthers are covered with pollen all round, affording abundant booty to pollen-collecting bees, while the flat layer of nectar only attracts flies and other short-tongued insects.

As these visitors creep over the inflorescences they chiefly effect cross-pollination, though autogamy is also often brought about. The latter may also take place automatically, for in many flowers the stigmas are vertically below an anther. Kerner states that geitonogamy occurs.

VISITORS.—Herm. Müller gives the following list.—

A. Coleoptera. (*a*) *Anisotomidae*: 1. Anisotoma obesa *Schmidt*, nect-lkg. (?). (*b*) *Elateridae*: 2. Athous vittatus *F.*; 3. Cryptophypnus pulchellus *L.* (*c*) *Scarabaeidae*: 4. Oxythyrea stictica *L.*, freq., dvg. the delicate parts of the flowers; 5. Phyllopertha horticola *L.*, devouring the petals and other parts of the flowers. 6. Trichius fasciatus *L.*, freq., do. (Borgstette). (*d*) *Nitidulidae*: 7. Meligethes, freq. **B. Diptera.** (*a*) *Empidae*: 8. Empis tessellata *F.*, skg. (Budd.). (*b*) *Muscidae*: 9. Echinomyia fera *L.* (*c*) *Syrphidae*: all freq., skg. and po-dvg.: 10. Eristalis arbustorum *L.*; 11. E. nemorum *L.*; 12. E. sepulcralis *L.*; 13. E. tenax *L.*; 14. Helophilus floreus *L.*; 15. H. pendulus *L.* **C. Hymenoptera.** 16. Halictus sexnotatus *K.*, po-cltg.

The following were recorded by the observers, and for the localities stated.—

Sprengel mentions Meligethes ('flower-beetle') and Phyllopertha horticola *L.* ('smaller cockchafer'). Knuth, only the humble-bee Bombus terrester *L.* ♀, vainly seeking for nectar in the marginal flowers. Alfken (Bremen), 3 bees—1. Andrena albicans *Müll.* ♀, skg. and po-cltg.; 2. A. labialis *K.* ♂; 3. A. tibialis *K.* ♀, po-cltg. von Fricken (Westphalia), the Scarabaeid Trichius abdominalis *Mén.* MacLeod (Flanders), 2 hover-flies, an Empid, a beetle, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 373). Scott-Elliot (Dumfriesshire), 2 hover-flies ('Flora of Dumfriesshire,' p. 84).

1213. V. Lantana L. (Kirchner, 'Flora v. Stuttgart,' p. 671; Schulz, 'Beiträge,' II, p. 95; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 126.)—Kirchner says that the mechanism of the white flowers of this species resembles that of V. Opulus, but automatic self-pollination is rendered still more easy, for the anthers are placed almost vertically over the stigma; less nectar is also secreted. Schulz describes the flowers as protogynous, with persistent stigmas. The stamens are at first curved inwards, but afterwards incline outwards over the edge of the expanded corolla, so that automatic self-pollination does not usually take place. Kerner states that geitonogamy is effected automatically.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Schulz, numerous flies, Hymenoptera, and beetles. Loew (Berlin Botanic Garden), the Bibionid Bibio laniger *Mg.* ♂, skg. F. F. Kohl (Tyrol), the true wasp Leionotus rossii *Lep.* von Dalla Torre and Schletterer (Tyrol), the humble-bee Bombus pomorum *Pz.*

387. Weigela Thunb.

Flowers red to white in colour, infundibuliform to campanulate, belonging to class **Hb**; with nectar secreted by a green swelling between the base of the style and the corolla.

1214. W. rosea Lindl. (=Diervilla florida *Sieb. et Zucc.*). (Herm. Müller, 'Weit. Beob.,' III, pp. 73-4; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller states that in the flowers of this species the base of the corolla is a narrow tube

12 mm. long and 2–3 mm. in diameter, which suddenly expands to two or three times that width; a total length of about 27 mm. being attained. The throat is 8–10 mm. in diameter, so that a bee of the size of Osmia rufa *L.* ♀ (which Müller observed as a particularly frequent po-cltg. or nect-skg. guest) has room to creep right in, and reach the nectar with its extended proboscis; larger humble-bees, on the contrary, cannot enter the flower. When the above-named bee creeps into the entrance of the flower, it first touches the 2–5 lobed stigma, which projects beyond the stamens, and dusts it with pollen brought from other flowers. The bee then encounters the anthers, which surround the throat of the corolla, and its hairy covering takes up a fresh supply of pollen. Stadler describes the flowers as protogynous, but says that automatic self-pollination is not excluded ('Beiträge').

The corollas remain persistent for a considerable time, and even assume a darker rose-red colour than when the stigma and anthers were mature. The oecological meaning of this is the same as in Ribes sanguineum and R. aureum. *Cf.* p. 419, and Vol. I, p. 86.

VISITORS.—Besides Osmia rufa *L.* ♀, Herm. Müller observed two other bees (Halictus leucopus *K.* ♀, and H. sexnotatus *K.* ♀), both creeping entirely into the flower: also a po-dvg. beetle (Dasytes sp.).

Alfken saw the bee Prosopis hyalinata *Sm.*, asleep in the early morning in the hollow of the flower.

I have frequently noticed in my garden the humble-bee Bombus agrorum *F.* ♀, pushing the front part of its body into the flower, and inserting its proboscis far enough to suck the nectar. Though cross-pollination is regularly effected in this way, I have never remarked the setting of fruit. I have also seen the same humble-bee as a visitor in Mecklenburg and Pomerania.

388. **Diervilla** Tourn.

1215. D. japonica Thunb.—Stadler ('Beiträge') describes the flowers of this species as protogynous; so is the var. *amabilis* (Francke, 'Beiträge').

1216. D. canadensis Willd. (= D. trifolia *Moench*). (Francke, op. cit.; Loew, 'Blütenbiol. Beiträge,' II, pp. 61, 63; W. J. Behrens, 'D. Nekt. d. Blüten.')—This species is protogynous, and possesses a nectary beset with long clavate hairs.

1217. D. floribunda Sieb. et Zucc.—This and other related species agree with D. canadensis.

389. **Aucuba** Thunb.

1218. A. japonica Thunb.—

VISITORS.—Plateau (Belgium) noticed po-dvg. Muscids (Calliphora vomitoria *L.*, and Musca domestica *L.*).

390. **Symphoricarpos** Dill.

Flowers reddish in colour, bell-shaped, homogamous; with concealed nectar, secreted, according to Delpino, by a papillose gibbosity on one side of the corolla. Bonnier says that all the parts of the flower are very rich in sugar. He does

not consider the swelling at the base of the style as a nectary; but Hermann Müller, on the other hand, describes it as such. The swelling in question appears to me to possess the characters of a nectary in so marked a form that I concur with the latter view.

1219. S. racemosus Michx. (Herm. Müller, 'Fertilisation,' pp. 292–3, 'Weit. Beob.,' III, p. 78; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 81, 'Blütenbesucher,' I, p. 16, 'Blütenbiol. Beob. in Thüringen,' 'Bloemenbiol. Bijdragen'; MacLeod, Bot. Centralbl., Cassel, xxix, 1887, p. 119; Loew, 'Blütenbiol. Floristik,' p. 250, and bibliography.)—The slightly odorous pendulous flowers of this species obviously belong to class **Hw**. They are 7–8 mm. long and 5 mm. broad, and therefore, according to Hermann Müller, conveniently receive the head of a wasp (5 mm. broad, 2–2½ mm. thick). Wasps actually appear to be the most frequent visitors and pollinators, but, in my opinion, the size of the heads of other guests, such as hover-flies and bees, corresponds equally well to the internal dimensions of the flowers.

Where the pendulous bell-shaped flower is broadest, its inner surface is closely beset with numerous long hairs. These stretch from the five lobes of the corolla to the middle of the bell, and thus not only effectively protect the abundant nectar from the rain, but also prevent it from running out.

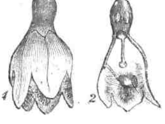


FIG. 172. *Symphoricarpos racemosa, Michx.* (after Herm. Müller). (1) Flower seen from the side. (2) Ditto, in longitudinal section (× 2½).

The five epipetalous stamens spring from about the middle of the bell. They converge so that the introrse anthers are placed at the entrance of the flower, in the lowest part of the lining of hairs. Immediately above the anthers, where the bell narrows, the simultaneously maturing stigma is situated.

When a nectar-seeking insect, with a head corresponding to the size of the bell, pushes this into the flower, it first of all comes into contact with the five anthers, getting covered with pollen, and then one side of it touches the stigma. Hermann Müller says, however, that little or no pollen remains on the insect's head by the time the stigma is reached, partly because this is but slightly sticky, partly because any grains that happen to adhere are brushed off again by the thick coating of hairs which lines the corolla. It is only when withdrawing from the bell that the head of the insect, now wet with nectar, becomes thoroughly covered with pollen, part of which is transferred to the stigma of the next flower visited. Cross-pollination is thus effected. In the absence of insect visitors, automatic self-pollination is probably always prevented, owing to the pendulous character of the flower, and the relative positions of anthers and stigma.

VISITORS.—I have seen the humble-bee Bombus agrorum *F.*, and the true wasp Vespa saxonica *F.*, skg., in Thuringia: in Schleswig-Holstein, Mecklenburg, and Pomerania, in spite of careful observation of the flowers, I have never seen a wasp visiting them, but only nect-skg. bees (Apis, Bombus terrester *L.*) and hover-flies (Eristalis sp., Syrphus ribesii *L.*, Syritta pipiens *L.*, po-dvg.): also (20. 7. '97), at

Heringsdorf in the island of Usedom, Apis mellifica *L.* ☿, skg., and Bombus lapidarius *L.* ☿, do., together with numerous nect-skg. sp. of Vespa, especially V. vulgaris *L.*, V. media *Retz.*, and V. sylvestris *Scop.*

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Diptera. *Syrphidae*: 1. Helophilus floreus *L.*, skg. (?) (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 2. Apis mellifica *L.* ☿, freq., skg., (H. M.); 3. Bombus agrorum *F.* ☿, skg. (H. M.); 4. B. pratorum *L.* ☿, do. (H. M.); 5. Eucera longicornis *L.* ♂, do. (H. M.); 6. Halictus sexnotatus *K.* ♀, freq., skg. and po-dvg. (H. M., Budd.); 7. H. smeathmanellus *K.* ♀, skg. (Budd.); 8. Megachile centuncularis *L.* ♂, do. (H. M.). (*b*) *Sphegidae*: 9. Ammophila sabulosa *L.*, do. (H. M.). (*c*) *Vespidae*: 10. Eumenes pomiformis *F.* (Budd.), do.; 11. Odynerus sp., perforating the flowers from outside (H. M.); 12. Polistes diadema *Ltr.* (H. M.); 13. P. gallica *L.*; 14. Vespa media *Retz.* (H. M.); 15. V. rufa *L.* (H. M.); 16. V. saxonica *F.* (H. M.); 17. V. sylvestris *Scop.* ♀, skg. (H. M., Budd.).

Loew noticed the following in Brandenburg ('Beiträge,' p. 42).—

A. Diptera. (*a*) *Muscidae*: 1. Lauxania aenea *Fall.* (*b*) *Syrphidae*: all skg.: 2. Eristalis arbustorum *L.*; 3. Helophilus floreus *L.*; 4. Syritta pipiens *L.*; 5. Syrphus balteatus *Deg.*; 6. S. corollae *F.* **B. Hymenoptera.** (*a*) *Apidae*: all skg.; 7. Halictus cylindricus *F.* ♂: 8. H. malachurus *K.* ♂. (*b*) *Vespidae*: all skg.; 9. Eumenes pomiformis *F.*; 10. Odynerus parietum *L.* 11. O. parietum *L.* (= O. renimacula *Lep.* ♀); 12. Vespa sylvestris *Scop.* ☿.

The following were recorded by the observers, and for the localities stated.—

Alfken (Bremen), a Cerambycid (Judolia cerambyciformis *Schr.*, freq.), 2 true wasps (Vespa media *Retz.* ☿, and V. sylvestris *Scop.*), and 11 bees—1. Andrena convexiuscula *K.* ♂; 2. Bombus agrorum *F.* ☿; 3. B. derhamellus *K.* ♀ and ☿; 4. B. hortorum *L.* ☿; 5. B. jonellus *K.* ☿ and ♂, skg.; 6. B. lucorum *L.* ☿ and ♂; 7. B. muscorum *F.* ♂; 8. B. pratorum *L.* ☿ and ♂; 9. B. terrester *L.* ♂; 10. Podalirius parietinus *F.* ♀; 11. Psithyrus vestalis *Fourcr.* ♂. Schmiedeknecht (Thuringia), the bee Andrena combinata *Chr.* von Dalla Torre (Tyrol), the bee Halictus morio *F.* ♀, very freq. MacLeod (Flanders), numerous moths, skg. (Bot. Centralbl., Cassel, xxix. 1887). C. Schröder (Rendsburg, 9 and 10 p. m.), numerous Noctuids of the genera Agrotis, Mamestra, and Plusia, skg.

391. Linnaea Gronov.

Flowers white in colour, homogamous, provided with nectar-guides on their inner surface; with entirely concealed nectar, secreted by a thickened part of the receptacle between the bases of the shorter filaments.

1220. L. borealis L. (Herm. Müller, 'Alpenblumen,' pp. 393–4; Loew, 'Blütenbiol. Floristik,' p. 249; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.')—The nectar in this species is protected from rain by the position of the flower, which hangs obliquely downwards. The hairs on the inner surface of the corolla perhaps serve as a protection against the smaller creeping insects. Cross-pollination is favoured by the fact that the freely secreting bilobed stigma projects far beyond the anthers, which mature simultaneously. Hermann Müller considers that automatic self-pollination is only possible in flowers that are unusually pendulous. Perhaps, however, pollen which remains clinging to the hairs lining the corolla may sometimes reach the stigma.

In plants from Tegel, near Berlin, Loew ('Blütenbiol. Floristik.,' p. 250) observed but a very small quantity of pollen, which was probably functionless, for the flowers never became fertilized. Loew suggests that a fungus parasitic in the anthers may have been the cause of this.

Kerner describes the flowers as funnel-shaped, 10–12 mm. long, and possessing an odour of vanilla. He considers that they permit the access of tolerably short-tongued insects.

VISITORS.—Herm. Müller (Alps) observed 3 flies and a Lepidopterid; and

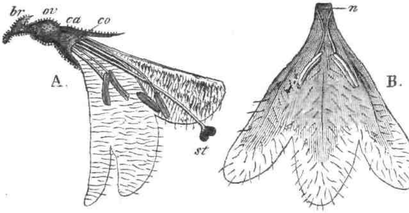


FIG. 173. *Linnaea borealis, L.* (after Herm. Müller). *A.* Flower seen from the side, after removal of the right half of calyx and corolla (× 7). *B.* Lower half of the corolla, with the epipetalous stamens and the nectary. *br*, bract; *ca*, calyx; *co*, corolla; *n*, nectary; *ov*, ovary; *st*, stigma.

Loew (Brandenburg) noticed the Dolichopodid Neurigona quadrifasciata *F.*, skg. (?) ('Beiträge,' p. 44).

392. Lonicera L.

Flowers belonging to classes **H** or **L**; homogamous, protogynous, or protandrous; with concealed nectar, secreted by the receptacle or in a pouch of the corolla.

1221. L. Periclymenum. (Herm. Müller, 'Fertilisation,' pp. 295–7, 'Weit. Beob.,' III, p. 75; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892; MacLeod, op cit., v, 1893, pp. 390–1; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 90, 156, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 234–5, Bot. Centralbl., Cassel, lx, 1894, pp. 41–4; 'Bl. u. Insekt. a. Helgoland'; Warnstorf, Schr. natw. Ver., Ver., Wernigerode, xi, 1896.)—The protandrous flowers of this species belong to class **Lm.** Hermann Müller describes them as homogamous, and gives the following illustration (Fig. 174), which applies to both L. Periclymenum and L. Caprifolium, except that in the latter the corolla-tube is 5–8 mm. longer.

What is represented in the accompanying illustration (Fig. 174) can be always observed in full daylight. I gave a similar description of the flowers of L. Periclymenum, after investigating them at midday, and observing visits of the diurnal hawk-moth Macroglossa stellatarum *L.* ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 80).

At the end of July, 1894, I studied the flower mechanism of the species (adapted to long-tongued nocturnal Sphingids) at Nieblum in the island of Föhr. This

climbing shrub had been cultivated there, and grown very luxuriantly, the bloom being remarkably fine during that year. I found very noticeable deviations from the description of Hermann Müller.

The buds are vertical, and the anthers dehisce within them between 6 and 7 p.m.; the stigma becoming receptive at the same time. But automatic self-pollination cannot take place, because the stigma projects 2 mm. beyond the longest stamens. (*Cf.* Fig. 175, 1.)

The first flowers open about 7 o'clock; by 8 most of the flowers have already closed. The lower lip of the corolla first separates from the upper one, then the stamens successively protrude from under the latter, while the end of the style is still held fast by its hood-like tip. More rarely the style protrudes before the stamens. The flower now gradually sinks, passing from the vertical to the horizontal position. This rotation through 90° is complete by the time the style and stamens have escaped from the upper lip, and the former curves down between the stamens till it rests on the horizontal or at first slightly curved under-lip.

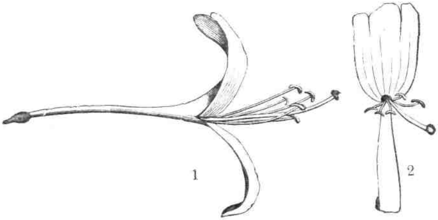


FIG. 174. *Lonicera Caprifolium*, *L.* (after Herm. Müller). (1) Flower, natural size, seen from the side. (2) Ditto, seen from the front. The stigma projects beyond the anthers, and is therefore first touched by visitors, so that it receives pollen from other flowers.

At the same time a strong odour is exhaled; this is very faint during the day. Hover-flies (Syrphus sp.) at once make their appearance, and settle on the anthers to devour the pollen, though frequently they alight on the stigma, and must therefore occasionally effect crossing. The versatile anthers are placed in front of the entrance to the flower, with their dehisced sides facing upwards or outwards, so that the pollen which covers them must be rubbed off by the under-surface of every hawk-moth probing for nectar. This is secreted by the ovary and lodged in the corolla-tube (about 25 mm. long), which at this stage is straight. The style projects some 25 mm., but, as already described, is curved downwards to such an extent at this stage that contact of hawk-moths with the stigma is impossible. (*Cf.* Fig. 175, 2.)

On the following morning the flowers present quite a different appearance, though they are still of a whitish colour. The anthers, if insect-visits have taken place, are destitute of pollen, and the style has changed its position. It is moving upwards, and now lies between or slightly below or above the stamens. This upward movement is completed by the time new buds are opening, i. e. between

7 and 8 p. m.: the filaments have meanwhile curved downwards, and their anthers shrivelled so much as to look like little withered hooks.

The flower has now reached its second, purely female, stage. The style projects forwards above the stamens, which, as already stated, are now curved downwards, and its tip has bent a little upwards. It follows that the stigma now dominates the entrance to the flower (Fig. 175, 3), and a visiting hawk-moth is sure to touch it with the under-side of its body, effecting cross-pollination if a flower in the first stage has previously been visited.

In the course of the day several other changes have taken place. The upper- and under-lips have rolled up more or less, so that the surface rendering the flower conspicuous has become increasingly smaller. At the same time there

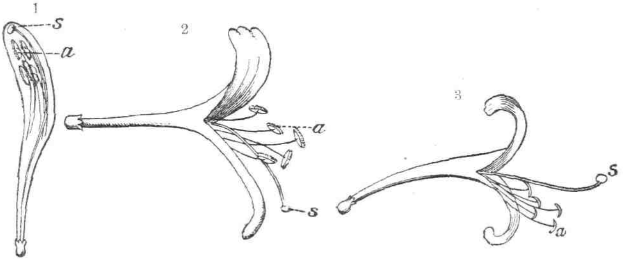


FIG. 175. *Lonicera Periclymenum*, *L.* (from nature; × 1). (1) Bud shortly before opening: the stigma is already mature, and the stamens have dehisced, but automatic self-pollination is prevented by the erect position and the greater length of the style. (2) Flower on the first evening: the pollen-covered anthers are in front of its entrance, the style is bent downwards so much that the stigma is not liable to be touched by hawk-moths: the upper- and under-lips are but slightly curved, and are white in colour. (3) Ditto, on the second evening, the style has curved upwards so much that the stigma is in front of the entrance to the flower; on the other hand, the stamens have curved downwards and the anthers are shrivelled; the upper- and under-lips are rolled back so as to occupy less space, and have become yellow. *a*, anther; *s*, stigma.

has been a gradual change of colour, the corolla, originally white inside and red outside, being now bright yellow. This change is completed by the evening, so that just before the fresh buds open there are no more pure white flowers to be seen.

The meaning of these facts in relation to pollination is obvious. Hawk-moths are attracted from a distance by the fragrance of the flowers, when nearer by the conspicuous inflorescences, and when quite close by the more clearly visible blossoms, i. e. the brighter and larger red-and-white ones in the first stage. The moths therefore visit these first, and afterwards go to the duller yellow flowers in the second stage, which are also smaller, owing to the rolling up of the ends of the petals. The pollen of the former is thus transferred to the latter. Although the two stages are so sharply outlined against the clear evening sky that it is possible to distinguish them at once, yet I was not able to confirm the above explanation by direct observation, for the movements of the hawk-moths which visit the flowers (Sphinx ligustri *L.*, and S. convolvuli *L.*) are so extremely rapid, and their approach is

so noiseless, that I found it impossible to discriminate which flowers were first visited by them.

The flowers in the second stage, with curved corolla-tubes, assume a darker tint in the course of the next few days, ultimately becoming a dirty orange-brown colour. The tips of the petals roll up more and more, and the fragrance exhaled in the evening gets less and less, but the position of the stamens and style remains the same. A certain amount of nectar is still secreted, and the stigma continues receptive for a time. Although the visits of hawk-moths become less frequent, the possibility of cross-pollination remains for some days.

Warnstorf states that inside the basal half of the corolla-tube, in line with the narrow under-lip, there is a longitudinal yellow ridge, indicated externally by a groove. The surface of this ridge is beset with small sessile glands secreting abundant nectar, the little drops of which collect in the base of the tube. An insect must possess a proboscis at least 15 mm. long in order to reach the beginning of this store. The style with its capitate stigma usually projects about 28 mm. from the corolla. Self-pollination is rendered very difficult, if not quite impossible, in such flowers. There are, however, others in which the stigma only projects about 1 mm. beyond the anthers, and here it is obvious that autogamy is greatly facilitated should insect-visits fail. The anthers dehisce in 30–40 minutes after the flower has opened. The pollen-grains are white in colour, sticky and coherent, tetrahedral, rendered opaque by numerous short spinose warts, and 88–100 μ in diameter.

Kerner and Warnstorf give the same hour for the opening of the flowers as myself; the former also states that the fragrance is strongest from 6 p.m. till midnight. He further describes the subsequent curving of the corolla-tube, adding that in this way direct contact between stigma and anthers, and therefore automatic self-pollination, may be brought about. I have not myself seen this; in the flowers in the island of Föhr it is almost impossible, the stigma projects so far beyond the anthers. My own observations in Helgoland prove that the mechanism is not everywhere the same. Here the buds are quite horizontal; except that in free inflorescences not crowded by others they are at first vertical, subsequently becoming inclined. Anthers and stigmas mature simultaneously, and three of the stamens are as long as the style, so that their pollen-covered anthers must touch the stigma, automatic self-pollination being therefore inevitable. The two other stamens are shorter by the length of an anther, and consequently serve for cross-pollination only. The secretion of nectar is so copious that the corolla-tube is often half-filled, giving access to Lepidoptera with a short proboscis. Even long-tongued humble-bees can obtain part of the spoil, at the same time effecting cross-pollination.

Hermann Müller observed a reduction of the corolla-tube from 22–5 mm. in length to 6 mm. in plants growing under 'unnatural conditions of life,' being subjected to the drip from a roof, which apparently killed them.

Visitors.—In Föhr, besides the above-named legitimate pollinators (Sphinx convolvuli and S. ligustri), I observed other Sphingids (Macroglossa stellatarum *L.*, Deilephila elpenor *L.*, Smerinthus ocellatus *L.*), a Noctuid (Plusia), and po-dvg. hover-flies (Syrphus, Eristalis, Rhingia, Syritta). I have also seen the humble-bee Bombus hortorum *L.* ♀, skg. legitimately and effecting pollination. This insect cannot, indeed, get all the nectar, but obtains a considerable part of it. On the island of

Amrum I specially observed Plusia gamma *L.*, freq., which also sucked legitimately and effected pollination. This moth was so zealous about the matter that I was able to remove it from the flowers with my fingers.

Herm. Müller only observed the humble-bee Bombus hortorum *L.* ♀, but supposed visits to be made by nocturnal hawk-moths as well. He makes the following remarks about the humble-bee mentioned:—'The bee wasted considerable time in obtaining a convenient position for sucking, and it crawled from the broad upper-lip to the mouth of the tube without touching the stigma and anthers; and the amount of honey it obtained must have been small, for after visiting a few flowers it flew away, though the plants were in full bloom. Bees, therefore, are only accidental visitors, which have had no influence in developing the special characters of the flower' ('Fertilisation,' pp. 295–7).

The following were recorded by the observers, and for the localities stated.—

Knuth (Helgoland) 2 hawk-moths (Deilephila galii *Rott.*, and Macroglossa stellatarium *L*), the Noctuid Plusia gamma *L.*, and small Noctuids (Bot. Jaarb. Dodonea, Ghent, viii, 1896, p. 44). Heinsius (Holland), the humble-bee Bombus hortorum *L.* ♂, freq., skg., and the po-dvg. hover-fly Melanostoma hyalinata *Fall.* ♀ (op. cit. iv, 1892, pp. 115–16). MacLeod (Belgium) noticed two humble-bees, skg. (Bombus hortorum *L.*, and B. agrorum *F.*); also the diurnal hawk-moth Macroglossa stellatarum *L.*, skg. Scott-Elliot (Dumfriesshire), 3 Lepidoptera ('Flora of Dumfriesshire,' p. 84). Willis observed (in the neighbourhood of the south coast of Scotland) the humble-bee Bombus hortorum *L.* ♀, freq., skg. ('Fls. and Insects in Gt. Britain,' Part I).

1222. **L. caprifolium** L. (Herm. Müller, 'Fertilisation,' pp. 293–5; Kirchner, 'Flora v. Stuttgart,' p. 672; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 201, 208, 211.) —This species bears flowers adapted to nocturnal hawk-moths. The mechanism (Fig. 174) agrees with that of L. Periclymenum (Herm. Müller, Kirchner, Kerner), but the corolla-tube is about 30 mm. long, so that only those Sphingids with a proboscis of corresponding length can exhaust the nectar. Kerner describes the flowers as slightly protogynous, while Hermann Müller considers them to be homogamous. According to Kirchner, the corolla in the unfertilized stage is white or reddish-white internally and is tinged with pink externally, but later on assumes a bright yellow colour. Kerner says that, as in the last species, the fragrance is most pronounced between 6 p.m. and midnight, and that the flowers open in a few minutes, anthesis lasting three days. This would indicate that the mechanism of L. Caprifolium agrees with the description I have given above for L. Periclymenum, but I have not yet had an opportunity of confirming this opinion, to which I first gave expression in 1894, by actual observation. Kerner says that automatic self-pollination takes place when insect-visits fail.

Visitors.—Herm. Müller observed the following **Lepidoptera** (the figures in parenthesis give the length of proboscis in mm.).—

(*a*) *Sphingidae*: 1. Sphinx convolvuli *L.* (65–80); 2. S. ligustri *L.* (37–42); 3. S. pinastri *L.* (28–33); all these 3 can completely exhaust the nectar; 4. Deilephila elpenor *L.* (20–24); 5. D. porcellus *L.* (20); these 2 can get most of the nectar; 6. Smerinthus tiliae *L.* (3), vainly trying to suck. (*b*) *Noctuidae*: 7. Dianthoecia capsincola *Hb.* (23–5), as 4 and 5; 8. Cucullia umbratica *L.* ♀ (18–22), do.; 9. Plusia gamma *L.* (15), getting some nectar. (*c*) *Bombycidae*: 10. Dasychira pudibunda *L.* (0), as 6.

MacLeod (Belgium) saw a hawk-moth (Deilephila sp.).

1223. L. tatarica L. (Herm. Müller, 'Fertilisation,' p. 297.)—This Siberian species, cultivated in our public gardens and so forth, bears flowers with concealed nectar. Hermann Müller says that the corolla-tube is 6–7 mm. long, and secretes nectar in a shallow pouch at its base. The bright red flowers are homogamous; the anthers project a little beyond the stigma. Insects, while probing for nectar, touch the stigma with one side of their heads and the pollen-covered anthers with the other. When visits are repeated crossing is favoured, though, of course, self-pollination may also be effected. The latter may also take place automatically, for it is not unusual to find flowers in which the stigma touches one or two of the anthers.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (H. M.) ('Weit. Beob.,' p. 235) and myself (Kn.) ('Bloemenbiol. Bijdragen').—**A. Diptera.** *Syrphidae*: 1. Rhingia rostrata *L.* (Kn., H. M.), very common, skg. and po-dvg. **B. Hymenoptera.** *Apidae*: 2. Andrena albicans

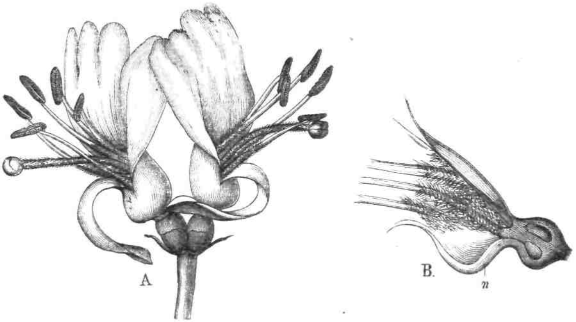


FIG. 176. *Lonicera nigra, L.* (after Herm. Müller). *A.* A pair of flowers, seen from the front. *B.* Lower part of a flower in longitudinal section (× 7). *n*, nectary.

Müll. ♀ (H. M.), vainly trying to suck; 3. Apis mellifica *L.* ☿ (Kn., H. M.), freq. skg.; 4. Megachile centuncularis *L.* ♂ (H. M.), skg. Alfken (Bremen), 3 humble-bees—1. Bombus derhamellus *K.* ♀; 2. B. sylvarum *L.* ♀; 3. B. lucorum *L.* ♀ and ☿. Morawitz (St. Petersburg), 2 leaf-cutting bees, freq.—Megachile willughbiella *K.*, and M. circumcincta *K.*

1224. L. Xylosteum L. (Herm. Müller, 'Fertilisation,' pp. 297–8; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 278.)—Hermann Müller describes the yellowish-white flowers of this species as homogamous. The corolla-tube is only 3–4 mm. long, so that the concealed nectar contained in a shallow pouch, and protected at the base of the tube with hairs, is accessible even to short-tongued insects. The stamens and style project far out of the flower, and the former diverge widely from the latter. It follows that insect visitors touch the stamens and stigma with opposite sides of their heads, and regularly effect cross-pollination. Failing such visitors, automatic self-

pollination may take place by the fall of pollen on the stigma. Humble-bees are the only insects which regularly effect crossing, their behaviour being as above described. Hermann Müller states that the honey-bee and flies sometimes do not touch the stigma at all.

Kerner describes the flowers as protogynous, and says that the stigma is at first in the line of access to the nectar. The style subsequently bends downwards, and the anthers take up the position previously occupied by the stigma.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller, bees, skg. (Apis mellifica *L.* ☿; Bombus agrorum *F.* ☿; B. pratorum *L.* ☿), and a few hover-flies (Empis opaca *F.*, freq., skg.; Rhingia rostrata *L.*, skg. and po-dvg.). Schmiedeknecht (Thuringia), the humble-bee Bombus distinguendus *Mor.* ♀. Rössler (Wiesbaden), the moth Grapholitha albersana *Hb.* Schletterer and von Dalla Torre (Tyrol), the humble-bee Bombus pomorum *L.*, ♀.

1225. **L. nigra** L. (Herm. Müller, 'Fertilisation,' p. 297, 'Alpenblumen,' pp. 394–5.)—The flowers of this species are homogamous, and belong to class **Hb**. The nectar is protected against rain by numerous hairs lining the corolla-tube. The stigma projects furthest from the flower, so that it is first touched by insect visitors, which necessarily effect cross-pollination. As the style curves downwards, automatic self-pollination results from the fall of pollen should insect-visits fail. (*Cf.* Fig. 176.)

VISITORS. — Herm. Müller saw the bees Apis and Halictus sp.; Ricca observed numerous humble-bees, bees, and flies (Atti Soc. ital. sc. nat., Milano, xiv, 1871).

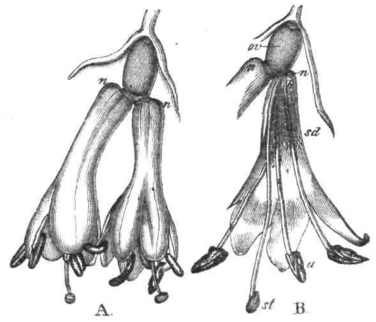


FIG. 177. *Lonicera caerulea*, *L.* (after Herm. Müller). *A.* A pair of pendulous flowers. *B.* A flower in longitudinal sections (× 4). *a*, anther; *h*, nectar; *n*, nectary; *ov*, ovary; *sd*, protecting hairs; *st*, stigma.

1226. **L. caerulea** L. (Hildebrand, 'D. Geschlechts-Vert. b. d. Pfl.,' p. 18; Ricca, Atti Soc. ital. sc. nat., Milano, xiv. 1871; Herm. Müller, 'Alpenblumen,' pp. 397–8.)—This species bears yellowish-white pendulous humble-bee flowers, described by Hildebrand as homogamous, by Ricca as protogynous. Hermann Müller says that the corolla-tube is about 10 mm. long, and that the nectar is most easily sucked by long-tongued bees, especially humble-bees. When these probe the flowers they first touch the stigma, and then the anthers, thus regularly effecting cross-pollination. In obliquely hanging blossoms automatic self-pollination can readily take place by the fall of pollen.

VISITORS.—Herm. Müller observed 12 Hymenoptera (including 5 species of humble-bees), 3 Syrphidae, 2 beetles, and 3 Lepidoptera.

Ricca noticed Bombus lapidarius *L.*, even at an altitude of 2,000–2,500 mm.

1227. **L. alpigena** L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 278; Schulz, 'Beiträge,' II, pp. 95–7; Herm. Müller, 'Fertilisation,' p. 298, 'Alpenblumen,' pp. 395–7.)—This species bears reddish-brown flowers belonging to class **Hw**, which are visited and pollinated by bees, humble-bees, and especially wasps. The pouch of the corolla-tube secretes very abundant nectar, protected by many hairs. The lower lip, directed obliquely downwards, forms a convenient platform for visitors. These must first encounter and touch the stigma, and then the anthers, so that cross-pollination is necessarily effected.

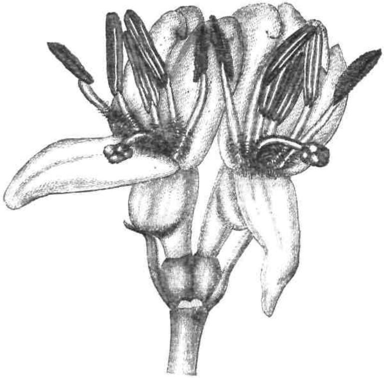


FIG. 178. *Lonicera alpigena, L.* (after Herm. Müller). A pair of flowers soon after opening, seen from the front (× 4). The one on the right side possesses a supernumerary stamen, but no corresponding corolla-lobe.

While Hermann Müller describes the flowers as homogamous, Kerner says they are protogynous, and that crossing is only possible at first, self-pollination being inevitable later on as the result of contact between stigma and anthers.

VISITORS.—Herm. Müller observed 9 Hymenoptera (including great numbers of 2 species of wasps), 2 Syrphidae, 2 Lepidoptera, and 2 beetles. Schulz specially noticed the diurnal hawk-moth Macroglossa stellatarum *L.*

1228. **L. iberica** Bieb.—Cultivated plants of this Caucasian species were investigated by Kirchner in Wurtemberg ('Beiträge,' pp. 62–3). The bright yellow flowers are slightly protogynous; the lower part of the corolla-tube rises abruptly to a height of 10 mm., and its upper part is 3 mm. long. The under-lip (10 mm. in length) is downwardly reflexed, while the upper one becomes erect and spreads cut. Insects probing for the nectar secreted in the base of the flower first touch the

stigma, which projects beyond the dehisced anthers for about 1–2 mm, so that cross-pollination is favoured.

VISITORS.—Kirchner observed Apis and the humble-bee Bombus lapidarius *L.*

1229. **L. implexa** Ait.—

VISITORS.—Schletterer (Pola) observed the ichneumon fly Gravenhorstia picta *Boie* (=Anomalon fasciatum *Gir.*).

1230. **L. etrusca** Santi.—

VISITORS.—Schletterer (Pola) observed a humble-bee (Bombus argillaceus *Scop.*), a Braconid (Bracon (Vipio) castrator *F.*), and a true wasp (Eumenes mediterranea *Krchb.*).

LII. ORDER *RUBIACEAE* DC.

LITERATURE.—Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 81, 'Grundriss d. Blütenbiol.,' p. 63; Schumann, 'Rubiaceae,' in Engler and Prantl, 'D. nat. Pflanzenfam.,' IV, 4, pp. 8–13.

Our native Rubiaceae are mostly small plants, bearing flowers of white or yellow colour, rarely red or blue, and only made conspicuous by being associated in crowded racemose inflorescences. Nectar is usually sparingly secreted by a fleshy disk on the ovary. Some foreign species, on the other hand (e.g. of Manettia, according to Fritz Müller), possess deeply concealed nectar accessible only to hawk-moths with a long proboscis or humming-birds with elongated beaks. Among German species only Asperula taurina and A. azurea, perhaps also Sherardia arvensis, belong to flower class **L**, while the other species of Asperula belong to *C*, and those of Galium to **E**.

Some foreign forms are dimorphous, e.g. species of Hedyotis (according to Treviranus); Borreria, Faramea, and Manettia (Fritz Müller); Mitchella, Knoxia, and Cinchona (Darwin); Chasalia, Nertera, Ophiorrhiza, and Luculia (Kuhn). Darwin ('Diff. Forms of Fls.') enumerates 17 genera with dimorphous flowers.

Fritz. Müller has described the flower mechanism of Posoqueria (Martha) fragrans, native to Brazil (Bot. Ztg., Leipzig, xxiv, 1866, p. 129; xxv, 1867; p. 80).

393. Sherardia Dill.

Flowers bright-violet in colour: perhaps belonging to class **L**, for the nectar is secreted by a fleshy disk surrounding the base of the style, and concealed in a narrow tube, so that it is most easily accessible to small Lepidoptera.

1231. **S. arvensis** L. (Herm. Müller, 'Weit. Beob.' III, pp. 71–2; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 385–6; Meehan, Bull. Torrey Bot. Cl., New York, xiv, 1887, pp. 238–9; Schulz, 'Beiträge,' I, p. 64; Kirchner, 'Beiträge,' p. 61.)—Hermann Müller describes this species as gynodioecious. The hermaphrodite flowers are somewhat larger than the female ones. The former are imperfectly protandrous, for the stamens with dehisced anthers curve out of the flower before the stigmas are fully mature. Not infrequently, however, the stigmas are completely receptive while the pollen-covered anthers are still on the same level, so that

automatic self-pollination easily takes place. Schulz says that the corolla-tube of hermaphrodite flowers is $2\frac{1}{2}$–$3\frac{1}{2}$ mm. long. Autumn flowers are self-fertilized, and do not open. Schulz also observed gynomonoecism. Kirchner found the hermaphrodite flowers to be homogamous.

VISITORS.—Herm. Müller supposed small Lepidoptera to be the pollinators of the flowers, but these have not yet been observed, and the visitors of the inconspicuous flowers are very few in number. Kirchner was fortunate enough to observe the following.—

A. Diptera. (*a*) *Syrphidae*: 1. Eristalis tenax *L.*, freq.; 2. Platycheirus scutatus *Mg.*, do. (*b*) *Muscidae*: 3. Siphona cristata *F.*; 4. Caenosia sp.; 5. Chlorops sp. **B. Hymenoptera.** *Apidae*: 6. Bombus agrorum *F.* **C. Hemiptera.** 7. Calocoris seticornis *F.*

394. Asperula L.

Flowers white, reddish, yellow, or blue in colour; arranged in cymose inflorescences; belonging to class **C**, or more rarely to **L**.

1232. A. cynanchica L. (Herm. Müller, 'Fertilisation,' pp. 302–3, 'Weit. Beob.,' III, pp. 72–3; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 201; Schulz, 'Beiträge,' I, p. 65; Loew, 'Blütenbiol. Floristik.,' p. 394.)—The flowers are white or reddish

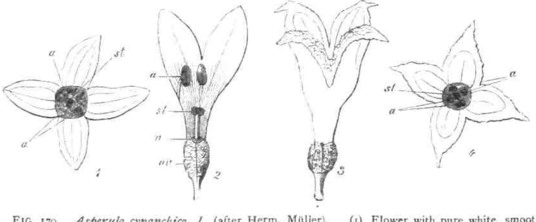


FIG. 179. *Asperula cynanchica*, *L.* (after Herm. Müller). (1) Flower with pure white, smooth petals, seen from above (× 7). (2) Ditto, after removal of half the corolla; seen from the side. (3) Flower with rough petals ornamented with red lines; seen from the side. (4) Ditto, seen from above. *a*, anther; *n*, nectary; *ov*, ovary; *st*, stigma.

in colour, and Kerner says that they smell like vanilla. Hermann Müller describes them as homogamous. The abundant nectar is concealed at the bottom of a corolla-tube 2 mm. long. In the middle of this are situated the two closely apposed capitate stigmas, while the converging anthers occupy the entrance to the flower. Insect visitors are likely to effect cross-pollination, for they usually touch the pollen and stigma with opposite sides of their proboscis. Automatic self-pollination can easily take place by the fall of pollen on the stigma. Hermann Müller was able to distinguish two different forms of flower in Thuringia; one with smooth, white, moderately obtuse corolla-lobes, the other with these lobes rough on the upper surface, ending in sharp recurved tips, and each marked with three red lines. Warnstorf describes the pollen-grains, examined in water, as yellow in colour, small, spheroidal, delicately striated, transparent, and about 25 μ in diameter.

Willis observed gynodioecism in England (Proc. Phil. Soc., Cambridge, ix, 1893).

VISITORS.—Herm. Müller observed the following in Thuringia.—

A. Coleoptera. (*a*) *Elateridae*: 1. Agriotes ustulatus *Schall.*, resting inactively on the flowers. (*b*) *Telephoridae*: 2. Danacea pallipes *Panz.*, resting inactively on the flowers; 3. Dasytes subaeneus *Schh.*, skg. (?); 4. Ebaeus thoracicus *Oliv.* **B. Diptera.** (*a*) *Bombyliidae*: 5. Systoechus sulphureus *Mik.*, skg. (*b*) *Empidae*: 6. Empis livida *L.*, freq., skg.; 7. Rhamphomyia sp., eagerly skg., in very large numbers. (*c*) *Muscidae*: 8. Siphona geniculata *Deg.*, freq., skg.; 9. Ulidia erythrophthalma *Mg.*, do. (*d*) *Stratiomyidae*: 10. Nemotelus pantherinus *L.*, skg. (*e*) *Syrphidae*: 11. Syritta pipiens *L.*, hovering and skg. **C. Hymenoptera.** *Apidae*: 12. Bombus agrorum *F.* ☿, casually trying to suck. **D. Lepidoptera.** (*a*) *Geometridae*: 13. Minoa murinata *Scop.*, skg. (*b*) *Rhopalocera*: 14. Coenonympha arcania *L.*, skg.

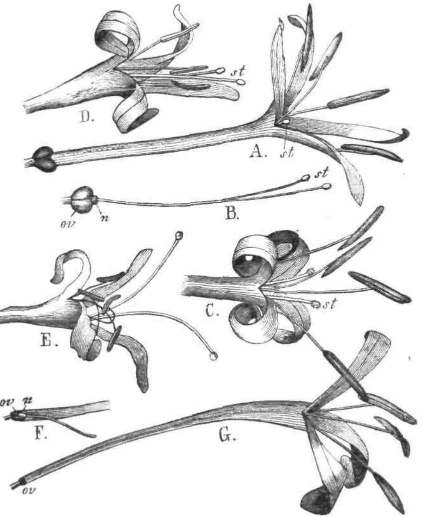


FIG. 180. *Asperula taurina, L.* (after Herm. Müller). *A.* Hermaphrodite flower, seen from the side. *B.* Pistil and nectary of the same flower. *C.* Another hermaphrodite flower with the stigmas more exserted. *D.* A third ditto, with long stylar branches. *E.* Half-withered flower, with the branches of the style even longer. *F.* Vestigial pistil of a male flower. *G.* A trimerous male flower (×7). *n*, nectary; *ov*, ovary; *st*, stigma.

Loew noticed the bee Exoprosopa picta *Mg.*, skg., in Steiermark ('Beiträge,' p. 51). MacLeod saw 2 flies in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 345).

1233. A. montana Waldst. et Kit. (=A. cynanchica, according to the *Index Kewensis*).—Kirchner ('Beiträge,' pp. 59–60) says that in the canton Valais the corolla-tube of this species is 4–5½ mm. long. The flowers are homogamous, with styles of varying length and persistent stigmas. In the long-styled form self-pollination is hindered, but in the short-styled one it easily takes place.

1234. A. glauca Bess. (=A. galioides *Bieb.*).—Schulz ('Beiträge') says that the white or reddish-white odorous flowers of this species are homogamous or slightly protandrous. As the anthers usually remain above the middle of the flower till all the pollen is shed, automatic self-pollination is inevitable.

Visitors.—Schulz states that these are numerous small insects of the orders Diptera, Hymenoptera, and Lepidoptera; but in many cases these undoubtedly only effect self-pollination.

1235. A. odorata L. (Sprengel, 'Entd. Geh.,' p. 84; Herm. Müller, 'Fertilisation,' p. 304, 'Weit. Beob.,' III, p. 73; Knuth, 'Bloemenbiol. Bijdragen.')—Hermann Müller says that the white flowers of this species, which smell of cumarin, possess the same mechanism as A. cynanchica. Warnstorf describes the pollen-grains as white in colour, ellipsoidal, smooth, about 25 μ long and 12–15 μ broad.

Visitors.—Herm. Müller (H. M.) and myself (Kn.) have observed the following.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Grammoptera levis *F.* (H. M.), not infrequent, po-dvg. (*b*) *Telephoridae*: 2. Dasytes sp. (H. M.). (*c*) *Mordellidae*: 3. Anaspis frontalis *L.* (H. M.), freq. (*d*) *Nitidulidae*: 4. Meligethes (H. M.), freq. **B. Diptera.** (*a*) *Empidae*: 5. Empis tessellata *F.* (H. M.), one, skg. (*b*) *Muscidae*: 6. Siphona geniculata *Deg.* (H. M.), freq., skg. (*c*) *Syrphidae*: 7. Eristalis nemorum *L.* (H. M.), skg.; 8. Rhingia rostrata *L.*, one, skg. (Kn.); 9. Syritta pipiens *L.*, freq., skg. (H. M., Kn.). **C. Hymenoptera.** *Apidae*: 10. Apis mellifica *L.* ☿, freq., skg. (H. M., Kn.); 11. Halictus cylindricus *F.* ♀, skg. (Kn.). **D. Lepidoptera.** *Microlepidoptera*: 12. Elachista sp., skg. (H. M.).

1236. A. taurina L. (Herm. Müller, 'Fertilisation,' pp. 303–4, 'Alpenblumen,' pp. 390–2.)—The white colour of the corolla, and its long (9–11 mm.) narrow tube, indicate that this species is visited by moths. It is andromonoecious, and the hermaphrodite flowers are markedly protandrous (Fig. 180). According to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 325–6), the stigmas, owing to curving of the stylar branches, are later on brought so close to the anthers of the neighbouring male flowers that geitonogamy is automatically effected.

Visitors.—Herm. Müller did not observe the actual pollinators, but saw a few casual visitors (a Bombylius, an Empis, an Echinomyia, a Syritta, and 2 beetles).

Loew (Berlin Botanic Garden) noticed a Syrphid (Melithreptus scriptus *L.*, po-dvg.), and 2 bees (Andrena nitida *Fourcr.* ♀, po-cltg.; Prosopis communis *Nyl.* ♂, settling on the stamens and po-dvg.).

1237. A. azurea Jaub. et Spach. (=A. orientalis *Boiss. et Hohen.*). (Herm. Müller, 'Weit. Beob.,' III, p. 73.)—Hermann Müller says that the flowers of this species conceal their nectar in a tube as long and narrow as that of A. taurina, but their blue colour indicates that they are pollinated by butterflies, not by moths.

1238. A. tinctoria L. (Herm. Müller, 'Weit. Beob.,' III, p. 72; Schulz, 'Beitrage,' I, p. 65.)—Hermann Müller says that in the homogamous flowers of this

species the corolla-tube is scarcely 2 mm. long: the anthers occupy its throat, and the two capitate stigmas are situated a little below the middle of it. Nectar-sucking insects touch the stigmas and anthers with opposite sides of their proboscis, and therefore usually effect geitonogamy or xenogamy. The stamens converge towards the end of anthesis, so that pollen can fall upon the stigmas, and effect automatic self-pollination as a last resort if insect-visits have failed. Schulz also observed protandry.

VISITORS.—Herm. Müller (Thuringia) saw a Muscid (Ulidia erythrophthalma *Mg.*, skg.), several small ichneumon flies, and a small Gelechid moth, skg. Rössler records the Pyralid Orobena limbata *L.*, for Wiesbaden.

1239. **A. stylosa** Boiss.—

VISITORS.—Loew saw Apis, skg., in the Berlin Botanic Garden.

1240. **A. scoparia** Hook. f., and 1241. **A. pusilla** Hook. f. (=A. Gunnii *Hook. f.*).—These two Tasmanian species are described by Treviranus as dimorphous (Bot. Ztg., Leipzig, xxi, 1863, p. 6).

395. Rubia L.

Flowers small, greenish; homogamous, with exposed nectar.

1242. **R. tinctorum** L. (Kirchner, 'Beiträge,' p. 69.)—Although the flowers of this species are united into cymose inflorescences, they are not at all conspicuous, owing to their small size and green colour. Kirchner gives the diameter of the flat corolla as 5 mm. When the flowers open, the almost sessile anthers have already dehisced. The two rounded stigmas are borne on such short styles that they are situated about the level of the lower part of the anthers. They remain in this position for some time after the anthers shrivel up, and continue to be receptive. Automatic self-pollination is easily effected, and regularly takes place. Kirchner, however, observed insect visitors (small sucking Hymenoptera and flies), by which crossing may be brought about. Nectar is secreted in the base of the saucer-shaped corolla-tube (only half a mm. deep), and is accessible to all comers.

396. Galium L.

Herm. Müller, 'Fertilization,' pp. 300–2.

Flowers white or yellow in colour; arranged in cymose inflorescences: with exposed nectar. Hermann Müller says that the transfer of pollen to the stigmas is chiefly effected by the feet and only to a lesser extent by the proboscis of insect visitors that creep about the inflorescences. Probably automatic geitonogamy of the small crowded flowers is possible in all species by the fall of pollen upon the stigmas of flowers at a lower level.

1243. **G. cruciata** *Scop.* (Darwin, 'Different Forms of Fls.,' p. 286; Kirchner, 'Flora v. Stuttgart,' p. 666, 'Neue Beob.,' p. 65.)—The inconspicuous greenish-yellow flowers of this species smell like honey, and are arranged in scanty inflorescences (helicoid cymes). Darwin and Kirchner describe them as andro-monoeciously distributed, the lower ones being male, and the upper ones hermaphrodite. Schulz ('Beiträge,' I, p. 66) investigated very numerous plants from different

localities, and only occasionally observed such relations. He found, on the contrary, that the first flowers to open in each main and lateral axis are hermaphrodite, while the later ones are mostly male. The hermaphrodite flowers are more or less distinctly protandrous, rarely homogamous. Self-pollination is therefore rare or impossible, despite the centripetal movement of the stamens.

VISITORS.—Schulz observed bees, and Schletterer (Pola) noticed the saw-fly Athalia rosae *L.*, var. cordata *Lep.*

In Dumfriesshire, 7 hover-flies and several Dolichopodids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 84).

1244. **G. Mollugo** L. (Herm. Müller, 'Fertilisation,' pp. 300–1, 'Weit. Beob.,' III, pp. 69–70; Knuth 'Bl. u. Insekt. a. d. nordfr. Ins.,' 'Blütenbiol. Beob. a. d. Ins. Rügen'; Schulz, 'Beiträge,' I, p. 67; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 344.)—The small white flowers of this species are arranged in conspicuous inflorescences. Hermann Müller describes them as protandrous. Like all our native Rubiaceae, they secrete nectar on a disk above the ovary, and surrounding the base of the style. The quantity is very small, and forms only a thin layer.

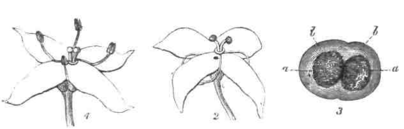


FIG. 181. *Galium Mollugo, L.* (after Herm. Müller). (1) Young flower, with erect stamens and styles. (2) Older flower with stamens curved out of it, and styles diverging. (3) Middle of the flower, seen from above, more highly magnified. *a*, stigma; *b*, fleshy disk of the ovary.

In younger flowers the stamens are erect, with anthers pollen-covered all over, while the two capitate stigmas are still closely apposed, but already receptive. The stamens subsequently spread out, and finally bend quite out of the flower; the two styles also diverge. In this second stage, therefore, cross-pollination is likely to result from the visits of insects. Schulz states that autumn plants in particular are frequently homogamous, and as in these the anthers are at first situated above the stigmas, self-pollination may take place. I have never observed the incurving of the stamens leading to autogamy that is described by Kerner as occurring in this species, G. infestum, and G. tricorne.

VISITORS.—I observed the following **Diptera,** skg., in the island of Sylt ('Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235).—

1. Coenosia tigrina *F.*; 2. Dolichopus aeneus *Deg.*; 3. Hylemyia sp.; 4. H. variata *F.*; 5. Sargus cuprarius *L.*; 6. Scatophaga stercoraria *L.*; 7. Spilogaster communis *R.-D.*; 8. S. duplaris *Zett.*; 9. S. duplicata *Mg.*; 10. Stomoxys stimulans *Mg.* ♀; 11. Thereva nobilitata *F.*; and in Rügen the beetle Cantharis fulva *Scop.*, po-dvg.

Herm. Müller gives the following list.—

A. Coleoptera. *Oedemeridae*: 1. Oedemera podagrariae *L.*, po-dvg. (Thuringia). **B. Diptera.** (*a*) *Bombyliidae*: 2. Anthrax flava *Mg.*, not infrequent, nect-lkg. (Thuringia); 3. Systoechus sulphureus *Mik.*, skg., probably piercing the

nectary (nect-lkg., Thuringia). (*b*) *Muscidae*: 4. Musca corvina *F.*; 5. Scatophaga merdaria *F.*, skg. (*c*) *Stratiomyidae*: 6. Odontomyia viridula *F.*, not infrequent, nect-lkg. (*d*) *Syrphidae*: 7. Melithreptus sp., po-dvg. (Buddeberg); 8. Merodon aeneus *Mg.*, po-dvg. (Thuringia); 9. Syritta pipiens *L.*, freq., skg. and po-dvg.; 10. Syrphus ribesii *L.*, do. (*e*) *Tipulidae*: 11. Pachyrhina crocata *L.*, skg. **C. Hymenoptera.** *Sphegidae*: 12. Ammophila sabulosa *L.* ♀.

The following were recorded by the observers, and for the localities stated.—

Alfken and Leege (Juist), the butterfly Pieris napi *L.*, and the Noctuid Plusia gamma *L.* Verhoeff (Norderney).—**A. Coleoptera.** *Telephoridae*: 1. Dolichosoma lineare *Rossi.* **B. Diptera.** (*a*) *Dolichopodidae*: 2. Dolichopus aeneus *Deg.* (*b*) *Empidae*: 3. Hilara quadrivittata *Mg.* (*c*) *Muscidae*: 4. Anthomyia sp. 5. Aricia incana *Wied.*; 6. Cynomyia mortuorum *L.*, skg.; 7. Hydrotaea sp., 1 ♂; 8. Lucilia caesar *L.*, skg.; 9. Miltogramma sp.; 10. Sarcophaga striata *F.*, skg.; 11. Sepsis cynipsea *L.* (*d*) *Syrphidae*: 12. Eumerus sabulosus *Fall.* ♀; 13. Melithreptus menthastri *L.* ♀, skg.; 14. Platycheirus clypeatus *Mg.*; 15. Syritta pipiens *L.*, skg. (*e*) *Therevidae*: 16. Thereva anilis *L.*, skg. **C. Hymenoptera.** (*a*) *Formicidae*: 17. Myrmica rubra *L.*; 18. M. rugulosa *Nyl.* a ☿. **Arachnida.** *Trombidiidae*: 19. Rhyncholopus phalangioides *Deg.* Verhoeff describes the last-mentioned mite as a constant visitor (Ent. Nachr., Berlin, xviii, 1892). Loew (Silesia) ('Beiträge,' p. 29), an Oedemerid (Chrysanthia viridis *Schmidt*), and a hover-fly (Melithreptus scriptus *L.*, skg.). MacLeod (Flanders), 3 flies and a beetle (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 386); (Pyrenees), 4 Muscids and 2 Syrphids (op. cit., p. 345). Scott-Elliott (Dumfriesshire), an Empid, and several other Diptera ('Flora of Dumfriesshire,' p. 86).

1245. G. sylvaticum L. (Kirchner, 'Flora v. Stuttgart'; Schulz, 'Beiträge,' I, p. 67.)—According to Kirchner and Schulz, the small white flowers of this species are protandrous, and their mechanism agrees with that of G. Mollugo; the stamens, however, do not bend outwards in the same way, but remain incurved, so that automatic self-pollination can easily take place.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth, the po-dvg. hover-fly Syritta pipiens *L.* ('Bloemenbiol. Bijdragen'). Herm. Müller (Bavarian Oberpfalz) ('Weit. Beob.,' III, p. 69).—**A. Coleoptera.** (*a*) *Cerambycidae*: 1. Leptura testacea *L.* ♂, dvg. the anthers. (*b*) *Lycidae*: 2. Dictyoptera sanguinea *Scop.*, resting inactively on the flowers. (*c*) *Oedemeridae*: 3. Oedemera flavescens *L.*, its mouth busy with the anthers. **B. Diptera.** (*a*) *Muscidae*: 4. Sarcophaga sp., freq., skg. (*b*) *Syrphidae*: 5. Melithreptus menthastri *L.*, skg. Loew (Switzerland) ('Beiträge,' p. 56)—2 Bombyliids, skg.: (Anthrax maura *L.*, and Argyromoeba sinuata *Fall.*), and the Syrphid Melanostoma barbifrons *F.*

1246. G. sylvestre *Pollich.* (Herm. Müller, 'Alpenblumen,' pp. 389–90; Schulz, 'Beitrage,' I, p. 67; Knuth, 'Bloemenbiol, Bijdrägen.')—The white flowers of this species agree essentially as regards their mechanism with those of G. Mollugo, but the stamens after dehiscing do not curve so far outwards. They vary between protandry and homogamy; in the latter case automatic self-pollination easily takes place. Hermann Müller and Schulz state that in the Alps the flowers are larger (5–7 mm. in diameter) than in the lowlands.

Visitors.—Herm. Müller observed 2 Syrphids and 12 Lepidoptera. Schulz saw flies, beetles, small bees, and small Lepidoptera (especially Noctuids). I only noticed the hover-fly Syritta pipiens *L.*, po-dvg., at Kiel.

MacLeod (Pyrenees) observed a variety of this species (possibly G. Lapeyrousianum) to be visited by a beetle, 3 Muscids, and 3 Syrphids. He describes it as belonging to flower class **C**, while the other species of Galium belong to **E**.

1247. **G. verum** L. × **G. Mollugo** L. (=G. ochroleucum *Wolf.*). (Knuth, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235.)—In the island of Sylt (2. 7. '93) I have seen numerous insects visiting in succession the flowers of G. verum *L.* and G. Mollugo *L.*, and bringing about an interchange of pollen. G. ochroleucum *Wolf.*, which grows along with these two species, proves that this crossing is effective, for it is a hybrid between them.

VISITORS.—I observed the following Diptera, skg.—

1. Coenosia tigrina *F.*; 2. Dolichopus aeneus *Deg.*; 3. Hylemyia sp. ♀. 4. H. variata *F.*; 5. Spilogaster communis *R.-D.*; 6. S. duplaris *Zett.*; 7. S. duplicata *Mg.*; 8. Stomoxys stimulans *Mg.* ♀.

1248. **G. verum** L. (Herm. Müller, 'Fertilisation,' p. 301, 'Weit. Beob.' III, p. 70; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 387; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 82–3, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235; Schulz, 'Beiträge,' I, p. 67.)—The plants of this species that I examined in the island of Röm possessed the following flower mechanism.—The buds are odourless, but when the corolla expands a very strong smell of cumarin is exhaled. (Kerner compares it to that of honey.) The flowers are only 4 mm. in diameter, but being crowded into dense inflorescences their intense yellow colour makes them conspicuous from a distance. They are markedly protandrous. In the first stage of anthesis the four stamens bend back so far that the lower parts of their filaments lie between the lobes of the flat expanded corolla. At the same time the upper parts of the filaments are curved upwards, so that the dehisced anthers are in the way of chance visitors. After these have completely or partly shed their pollen, the two styles, so far united, separate, grow a little, and raise the mature stigmas almost to the level occupied by the anthers during the first stage of anthesis.

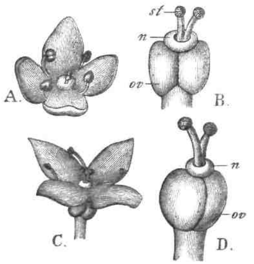


FIG. 182. *Galium sylvestre, Pollich* (after Herm. Müller). *A.* Young flower (× 7). *B.* Pistil and nectary of the same (× 16). *C.* Older flower (× 7). *D.* Pistil and nectary of the same (× 16). *n*, nectary; *ov*, ovary; *st*, stigma.

Autogamy occasionally results from the bending over of the filaments, till the anthers touch the stigmas. Automatic geitonogamy is frequently brought about by the fall of pollen from a higher flower on to the stigmas of a lower one. Lastly, the inflorescences are so crowded, and different stocks grow so close together, that xenogamy may possibly be effected by the wind. Hermann Müller describes a remarkable difference in the size of flowers from different plants, and indicates this in his illustration. (*Cf.* Fig. 183.) I have not noticed this in Röm, nor

any of the North Frisian Islands, where the plant grows in enormous numbers on the dunes. Schulz, however, observed considerable variations as to the size of flowers at Halle and in Thuringia, the extreme forms being connected by a large series of intermediate stages. He further remarked variations between strong protandry and complete homogamy. In the latter case automatic self-pollination is possible; but is prevented at a later stage by the stamens bending quite out of the flowers.

VISITORS.—Hermann Müller gives the following list (T.=Thuringia; O.= Bavarian Oberfals).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia bifasciata *Müll.*, dvg. the anthers (T.). (*b*) *Elateridae*: 2. Agriotes gallicus *Lac.* (T.). (*c*) *Mordellidae*: 3. Mordella aculeata *L.* (T.); 4. M. fasciata *F.* (T.). (*d*) *Oedemeridae*: 5. Oedemera podagrariae *L.*, po-dvg. (T.). (*e*) *Scarabaeidae*: 6. Cetonia aurata *L.*, dvg. the flowers (T.). **B. Diptera.** (*a*) *Bombyliidae*: 7. Anthrax flava *Mg.*, nect-lkg. (O.).

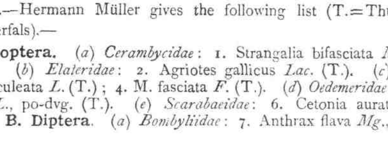


FIG. 185. *Galium verum, L.* (after Herm. Müller). (1) Young flower, from a plant with very small blossoms. The anthers are covered with pollen, and the stigmas are immature (× 7). (2) Older flower of the same plant with faded anthers, curved out of the corolla, and mature stigmas. (3) Flower of a plant with large blossoms, in the middle of anthesis: older than 1, younger than 2 (× 7). (4) Ditto, seen from the side.

(*b*) *Conopidae*: 8. Conops flavipes *L.*, nect-lkg. (*c*) *Muscidae*: 9. Ulidia erythrophthalma *Mg.* freq., nect-lkg. (T.). (*d*) *Syrphidae*: 10. Eristalis arbustorum *L.*, po-dvg. (T.). **C. Hymenoptera.** (*a*) *Apidae*: 11. Halictus cylindricus *F.* ♂, nect-lkg. (O.); 12. Prosopis sp. ♂, nect-lkg. (O.). (*b*) *Chrysididae*: 13. Holopyga ovata *Dahlb.*, nect-lkg. (T.). (*c*) *Tenthredinidae*: 14. Pachyprotasis rapae *K.*, nect-lkg. **D. Lepidoptera.** *Sphingidae*: 15. Macroglossa stellatarum *L.*, vainly searching for nectar (T.); 16. Zygaena lonicerae *Esp.* (*T.*).

The following were recorded by the observers, and for the localities stated.—

Knuth (Sylt and Föhr), numerous skg. **Diptera.**—1. Coenosia tigrina *F.*; 2. Dolichopus aeneus *Deg.*; 3. Hylemyia sp.; 4. H. variata *F.*; 5. Musca sp.; 6. Spilogaster communis *R.-D.*; 7. S. duplaris *Zett.*; 8. S. duplicata *Mg.*; 9. Stomoxys stimulans *Mg.*; the hover-fly Syritta pipiens *L.*, po-dvg., and the butterfly Epinephele janira *L.*, trying to suck: (Rügen), the beetle Strangalia melanura *L.*, po-dvg., and the hover-fly Syritta pipiens *L.*, do.: (Helgoland), Muscids, all skg.—1. Coelopa frigida *Fall.*; 2. Lucilia caesar *L.*; 3. Scatophaga stercoraria *L.*; 4. small undetermined sp. (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 34). Alfken (Bremen), the Chrysomelid Agelastica halensis *L.*, freq. MacLeod (Pyrenees), 2 Muscids (op. cit., iii, 1891, p. 345). Scott-Elliott (Dumfriesshire), 2 hover-flies and 4 Muscids ('Flora of Dumfriesshire,' p. 85).

1249. G. boreale L. (Axell, 'Om Anord. för Fanerog. växt. Befrukt.,' p. 97; Herm. Müller, 'Fertilisation,' pp. 301–2, 'Weit. Beob.,' III, p. 70, 'Alpenblumen,' p. 390; Schulz, 'Beiträge,' I, pp. 66–7.)—This species agrees with G. sylvestre as regards secretion of nectar, its slight protandry, and the relative positions of stamens and pistil. It follows that crossing is likely to be effected by insect-visits; falling

these, automatic self-pollination is possible. As in G. Mollugo, the withered stamens hang out of the flower.

A. Schulz, confirming the earlier observations of Axell, describes the flowers as more or less distinctly protandrous, but he found them to be homogamous in the Riesengebirge. In the last case automatic self-pollination is possible; later on, however, this is prevented by an outward curving of the stamens, although in very many flowers the stigmas are quite receptive at the time when the anthers are dehiscing. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1895) describes the flowers as homogamous or protogynous (op. cit., xxxviii, 1896).

VISITORS.—Herm. Müller observed a hover-fly and a Lepidopterid in the Alps, and the following in Westphalia and Thuringia.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia bifasciata *Müll.*, dvg. the anthers. (*b*) *Chrysomelidae*: 2. Luperus flavipes *L.* (*c*) *Dermestidae*: 3. Anthrenus claviger *Er.*, nect-lkg. (*d*) *Mordellidae*: 4. Mordella aculeata *L.*, in large numbers, nect-lkg. **B. Diptera.** (*a*) *Muscidae*: 5. Ulidia erythrophthalma *Mg.* (Thuringia). (*b*) *Syrphidae*: 6. Tropidia milesiformis *Fall.*, nect-lkg. **C. Hymenoptera.** (*a*) *Apidae*: 7. Prosopis brevicornis *Nyl.* ♂, skg. (*b*) *Tenthredinidae*: 8. Tarpa cephalotes *F.*, making erratic visits. **D. Lepidoptera.** *Microlepidoptera*: 9. A small moth, skg.

1250. **G. palustre** L. (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 97; Kirchner, 'Flora v. Stuttgart,' p. 664.)—Axell was the first to call attention to the protandry of this species. According to Kirchner, there is the same possibility of automatic self-pollination as in G. sylvaticum.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Verhoeff (Norderney), the Empid Hilara quadrivittata *Mg.*, and the Muscid Sepsis cynipsea *L.* MacLeod (Flanders), a hover-fly, a Siricid, an ichneumon fly, and a beetle (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 488). Scott-Elliot (Dumfriesshire), 2 hover-flies and 2 Muscids ('Flora of Dumfriesshire,' p. 85).

1251. **G. uliginosum** L. (Axell, 'Om Anord. för Fanerog. Växt. Befrukt.,' p. 97; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 387; Kirchner, 'Flora v. Stuttgart,' p. 665; Schulz, 'Beiträge,' I, p. 66.)—Axell was the first to recognize the protandry of this species. Kirchner says that the white flowers have the same mechanism as those of G. Mollugo. In autumn, according to Schulz, flowers are produced which do not open, but are fertilized cleistogamously.

Lindman describes the plants of the Dovrefjeld as first protandrous, then homogamous. The flowers possess an odour similar to that of G. verum; at first the pollen-covered anthers incline together above the middle of the flower, while the stigma is still immature, though it becomes receptive before all the pollen is shed. Even after the anthers have withered, they hang down loosely from their filaments, which remain curved inwards. The style then grows to such an extent that the stigmas occupy the position previously taken up by the anthers. Automatic self-pollination easily takes place during the homogamous stage.

1252. **G. Aparine** L. (MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 388; Kirchner, 'Flora v. Stuttgart,' p. 665; Knuth, 'Bloemenbiol. Bijdragen.')—

Kirchner describes the small white inconspicuous flowers of this species as protandrous. The stamens, however, do not bend back out of the flower, so that when the stigmas mature and diverge later on, they always touch the anthers, which, though dry, still carry pollen, so that automatic self-pollination is constantly secured. Darwin says that this is followed by the setting of fruit.

VISITORS.—I observed the po-dvg. hover-fly Syritta pipiens *L.*

In Dumfriesshire a wasp, an ichneumon fly, and a Muscid were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 87).

1253. **G. purpureum** L. (Schulz, 'Beiträge,' III, p. 97.)—Schulz states that the stamens are erect in the dark brownish-red flowers of this species, so that the anthers lie almost immediately above the stigmas, which mature simultaneously. By the fall of pollen autogamy is inevitably brought about.

VISITORS.—These are hover-flies, with small wasps and other little Hymenoptera, which usually effect self-pollination, though sometimes they undoubtedly bring about crossing.

1254. **G. tricorne** Stokes. (Herm. Müller, 'Weit. Beob.,' III, pp. 70–1.)—Herm. Müller states that nectar is abundantly secreted in this species, but the solitary white and yellowish-white flowers are so small that they do not receive many visitors. Automatic self-pollination therefore regularly takes place: the stamens do not bend outwards, but their anthers remain above the stigma, which matures simultaneously. Kerner says that automatic self-pollination is brought about by the anthers touching the stigmas as a result of incurving of the filaments.

VISITORS.—Herm. Müller only observed a Muscid (Anthomyia), nect-lkg.

1255. **G. lucidum** All. (=G. corrudaefolium *Vill.*). (Schulz, ''Beiträge,' II, pp. 97–8.)—Schulz states that the flower mechanism of this species resembles that of G. Mollugo. Protandry more or less marked. Self-pollination is usually prevented by outward curving of the stamens. The styles elongate considerably during anthesis.

VISITORS.—Schulz observed many small insects (flies, small Hymenoptera, beetles), which frequently effected self-pollination.

1256. **G. rubrum** L. (Schulz, op. cit.)—The flowers of this species are red or dark red in colour, and Schulz describes them as homogamous. Since the stamens bend outwards automatic self-pollination is not readily effected; but it is the only important means of fertilization, for Schulz, in spite of repeated observations in favourable weather, only saw 2 hover-flies visiting the flowers.

VISITORS.—*Vide supra.*

1257. **G. rubioides** L. (Kirchner, 'Beiträge,' p. 61.)—The plants of this species examined by Kirchner in the Berne Botanic Garden were protandrous. The flowers are white and shaped like a shallow funnel: the stamens are at first erect, but later on bend outwards, and their anthers drop off. It is only when this has taken place that the styles elongate and the stigmas diverge.

1258. **G. helveticum** Weigel. (Schulz, 'Beiträge,' II, p. 99.)—The whitish-yellow or greenish-yellow flowers of this species spread out into a star of about

$3\frac{1}{2}$–5 mm. in diameter. Schulz states that the stamens usually remain almost erect throughout anthesis. The anthers are therefore situated above the stigmas, which mature simultaneously, so that automatic self-pollination is inevitable. For the same reason, insect visitors probably always effect self-pollination.

VISITORS.—*Schulz observed numerous flies, beetles, small bees, and small Lepidoptera in the Alps.*

1259. **G. saxatile** L. (Herm. Müller, 'Weit. Beob.,' III, p. 69; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.' p. 83, 'Blütenbiol. Beob. a. d. Ins. Rügen.')—The plants of this species observed by me in the North Frisian Islands and at Kiel were protandrous, their flower mechanism agreeing in the main with that of G. Mollugo. The anthers dehisce before the styles diverge. In young flowers the stamens are erect, but as the styles elongate they separate so widely that they come to lie between the lobes of the corolla, while the stigmas assume the position at first occupied by the anthers. Automatic geitonogamy can easily take place, partly by the styles curving outwards till the stigmas touch the anthers of neighbouring flowers, partly by the fall of pollen upon the stigmas of adjacent blossoms of the same stock.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller, the Cerambycid Leptura livida *F.*, dvg. the flowers, and the Syrphid Syritta pipiens *L.*, freq., skg. and po-dvg. Knuth (Rügen), the Syrphid Eristalis sepulcralis *L.*, skg. and po-cltg. Scott-Elliot (Dumfriesshire), 3 hover-flies ('Flora of Dumfriesshire,' p. 86).

1260. **G. persicum** DC. (=G. coronatum *Sibth. et Sm.*).—

VISITORS.—Loew (Berlin Botanic Garden) saw an undetermined Pyralid.

397. Ixora L.

1261. **I. salicifolia** DC. (=I. fulgens *Roxb.*).—According to Willis (Proc. Phil. Soc., Cambridge, viii, 1892), the flowers of this species secrete nectar at the bottom of a long corolla-tube, so as to be accessible only to long-tongued insects. The pollen is shed on the still immature stigma. The style serves as an alighting place, and in the first stage of anthesis affords pollen to visitors, while in the second stage it terminates in the mature stigma.

1262. **I. coccinea** L.—As the last species.

398. Phyllis L.

1263. **P. Nobla** L. This species is native to the Canary Islands. It is markedly anemophilous (Delpino, Malpighia, Genova, iii, 1889).

399. Crucianella L.

1264. **C. stylosa** Trin. (=L. Asperula ciliata *Pochel*). (Francke, Inaug.-Diss., Halle, 1883; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 265, 267.)—Francke states that the pollen is shed while the flower is still a bud, and is

subsequently pushed out by the elongating style. The stigma then matures. Kerner describes the flower mechanism as follows. The long thin serpentiform style bears a thick stigma, which is held fast by the anthers, and gets covered with pollen. By elongation of the style, the stigma is raised to the dome-like top of the still closed flower. When insects alight the petals suddenly open, and the stigma springs out, dusting the visitors with pollen from below. The style with its maturing stigma now projects well out of the flower so that the latter is first touched by the hymenopterous or dipterous visitors. In this way crossing is necessarily effected. Failing insect-visits, the flower explodes, and its scattered pollen is wafted to the stigmas of neighbouring blossoms.

VISITORS.—*Vide supra.*

1265. **C. angustifolia** L.—The small flowers of this species are greenish-yellow in colour.

VISITORS.—Plateau observed the beetle Cassida nobilis *L.*, and a bee (Andrena sp.).

400. Coffea L.

1266. **C. arabica** L.—According to Bernoulli (Bot. Ztg., Leipzig, xxviii, 1869, p. 17), only small purely female fertile flowers are present at the beginning of anthesis. Ernst states that the hermaphrodite flowers are protandrous.

VISITORS.—Bourdillon chiefly observed Lepidoptera (Nature, London, xxxvi, 1887).

401. Nertera Banks et Soland.

1267. **N. depressa** Banks et Soland.—Francke describes this species as protogynous, autogamy being excluded (Inaug.-Diss., Halle, 1883).

402. Rondeletia L.

1268. **R. strigosa** Hemsl.—According to Penzig (Malpighia, Genova, viii, 1894, pp. 466–75), there are crowded yellow granules on the cup-shaped part of the corolla of this species, which closely mimic pollen-grains, and serve to attract insects.

LIII. ORDER *VALERIANAE* DC.

LITERATURE.—Knuth, 'Grundriss d. Blütenbiol.,' p. 63.

The flowers are aggregated into dense cymes, so that though usually small they are rendered conspicuous. The nectar is almost always secreted and concealed in a pouch or spur of the corolla-tube, so that most of the species belong to the flower class **S**, but those of the genus Centranthus are obviously members of **L**. Cross-pollination is secured by dichogamy, more rarely by dioecism (Valeriana dioica). Homogamy is exemplified among the smaller flowers.

403. Valeriana L.

Flowers whitish in colour, and arranged in corymbose capitate or paniculate cymes; protandrous or protogynous; with concealed nectar, secreted and concealed above the origin of the corolla-tube in a small pouch with a green fleshy base.

1269. V. officinalis L.—The small whitish or flesh-red, very fragrant flowers of this species are rendered conspicuous by aggregation into large inflorescences. Sprengel ('Entd. Geh.,' pp. 63–5) described them as protandrous, and this has been confirmed by Ricca (Atti Soc. ital. sc. nat., Milano, xiv, 1871) and Herm. Müller ('Fertilisation,' pp. 306–7, 'Alpenblumen,' pp. 469–70).

Five purple lines, which become paler in old flowers, serve as nectar-guides. The corolla-tube is 4–5 mm. long, and about $\frac{1}{2}$ mm. above its base there is a pouch containing the nectary, while above this the inner surface of the tube is beset with hairs.

In the first stage of anthesis the pollen-covered anthers project from the flower; in the second stage the 3 diverging stigmas also protrude.

Insects visiting the younger flowers will therefore cover their feet and the under-surface of their bodies with pollen, and transfer it to the stigmas of older flowers. As the stamens are curved outwards in the second stage, automatic self-pollination is prevented.

According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), the stamens do not project from the flower simultaneously, but in succession, subsequently curving outwards, so that the extrorse anthers easily pollinate neighbouring flowers in the female stage. The pollen-grains are white in colour, densely covered with spinose tubercles, ellipsoidal, usually truncated at one pole, up to 75 μ long and 44 μ broad.

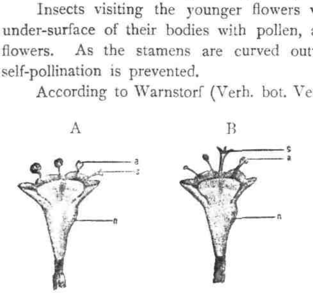


FIG. 184. *Valeriana officinalis, L.* (from nature, enlarged). *A.* Flower in the first (male) stage: the pollen-covered anthers (*a*) are above the corolla, the immature stigmas (*s*) are still curved to the side. *B.* Flower in the second (female) stage: the anthers (*a*) have shed their pollen, and are curved to the side, while the mature stigmas (*s*) project from the corolla. *n*, nectary.

The same authority states that by degeneration of the anthers purely female stocks are constituted, which are recognizable from a distance by their smaller and more crowded flowers (Schr. natw. Ver., Wernigerode, xi, 1896). The species is therefore gynodioecious.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Central Germany (Herm. Müller, 'Fertilisation,' p. 307, 'Weit. Beob.,' III, p. 98).—

A. Coleoptera. *Elateridae*: 1. Adrastus pallens *F. Er.*, inactive (H. M.). **B. Diptera.** (*a*) *Conopidae*: 2. Conops quadrifasciatus *Deg.*, skg. (H. M.); 3. C. scutellatus *Mg.*, do. (H. M.); 4. Sicus ferrugineus *L.*, do. (H. M.). (*b*) *Empidae*: 5. Empis livida *L.*, in very large numbers, skg. (H. M.); 6. E. rustica *L.*, do. (H. M.). (*c*) *Muscidae*: 7. Anthomyia sp., po-dvg. (Budd.); 8. Calliphora erythrocephala *Mg.*, freq., skg. (H. M.); 9. C. vomitoria *L.*, do. (H. M.); 10. Echinomyia fera *L.*, skg. (H. M.); 11. Lucilia cornicina *F.*, freq., skg. (H. M.); 12. Musca domestica *L.*, do. (H. M.); 13. Onesia floralis *R.-D.*, do., (H. M.); 14. Sarcophaga carnaria *L.*, do. (H. M.). (*d*) *Syrphidae*: 15. Chrysotoxum festivum *L.*, skg. and po-dvg. (H. M.); 16. Eristalis arbustorum *L.*, do. (H. M., Budd.); 17. E. horticola *Deg.*, do. (H. M.); 18. E. nemorum *L.*, do. (H. M.); 19. E. sepulcralis *L.*, do.

(H. M.); 20. E. tenax *L.*, skg. (H. M.); 21. Helophilus floreus *L.*, freq., skg. and po-dvg. (H. M.); 22. H. pendulus *L.*, do. (H. M.); 23. Syritta pipiens *L.*, do. (H. M.); 24. Volucella bombylans *L.*, do. (H. M.); 25. V. inanis *L.*, skg. (H. M.); 26. V. pellucens *L.*, skg. and po-dvg. (H. M.). (*e*) *Tabanidae*: 27. Tabanus luridus (H. M.). **C. Hemiptera.** 28. Pentatoma sp., skg. (H. M.). **D. Hymenoptera.** (*a*) *Apidae*: 29. Apis mellifica *L.*, ☿, freq. (H. M.); 30. Bombus pratorum *L.* ☿, skg. (H. M.); 31. Chelostoma nigricorne *Nyl.* ♂, do. (Budd.); 32. Halictus malachurus *K.* ♀ (Budd.); 33. Small sp. of Halictus ♀ and ♂, skg. (H. M.); 34. Sphecodes gibbus *L.*, do. (Budd.). (*b*) *Sphegidae*: 35. Crabro vexillatus *Pz.* ♀ (H. M.). **E. Lepidoptera.** 36. Epinephele hyperanthus *L.*, skg. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), a beetle, 16 flies, 6 Hymenoptera, and 5 Lepidoptera ('Alpenblumen,' p. 469). Loew, the Muscid Spilogaster angelicae *Scop.* ('Blütenbiol. Floristik,' p. 398). MacLeod (Flanders), 4 Syrphids, a Muscid, a Lepidopterid, and a beetle (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 392); (Pyrenees) a Lepidopterid, 3 Muscids, and 2 Syrphids (op. cit., iii, 1891, p. 346). Rössler (Wiesbaden), the butterfly Limenitis camilla *S. V.* Schenck (Nassau), the fossorial wasp Gorytes mystaceus *L.* Lindman (Dovrefjeld), several saw-flies and flies, a humble-bee, and 2 Nitidulids. Knuth (Kiel) ('Bloemenbiol. Bijdragen').—**A. Diptera.** *Syrphidae*: 1. Syrphus balteatus *Deg.*, po-dvg.; 2. Eristalis tenax *L.*, po-dvg. **B. Lepidoptera.** *Rhopalocera*: 3. Pieris sp., skg.: (Rügen)—**Diptera.** (*a*) *Muscidae*: 1. Aricia sp., skg. (*b*) *Stratiomyidae*: 2. Odontomyia viridula *F.*, freq., skg. (*c*) *Syrphidae*: 3. Eristalis pertinax *Scop.* ♀, skg. Loew (Berlin Botanic Garden), the hover-fly Eristalis nemorum *L.*, skg., and the honey-bee, do.: and on the var. altissima *Mchx.* —the scarabaeid Cetonia aurata *L.*, dvg. the flowers, and 2 bees—1. Andrena albicans *Müll.* ♀, skg. and po-dvg.; 2. Apis mellifica *L.* ☿, skg.

1270. V. dioica L.—Sprengel ('Entd. Geh.,' pp. 65–7), and subsequently Hermann Müller ('Fertilisation,' p. 307), state that, the male flowers being considerably larger than the female ones, the former are almost always visited first by insects, so that crossing is effected. The corolla-tube of the male flower expands upwards like a funnel, and is about 3 mm. long, while that of the female flower is only 1 mm. in length: the nectar is consequently accessible even to the shortest-tongued insects. Kerner says that the pseudo-hermaphrodite female flowers open 3–5 days earlier than the pseudo-hermaphrodite male ones. According to Hermann Müller the unisexual flowers are of different sizes, and the vestiges of the organs of the other sex are variable. Some male flowers have a very large corolla, and no trace of a pistil; others, a somewhat smaller corolla, and a vestigial pistil. There are also female flowers with large corolla and small pistil; others with large pistil and very small corolla. In rare cases hermaphrodite flowers also occur.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel) the honey-bee, skg. Herm. Müller, ditto, and also the bee Andrena albicans *Müll.* ♀, 2 hover-flies (1. Eristalis arbustorum *L.*, skg.; 2. Rhingia rostrata *L.*, po-dvg.), Tipula, a butterfly (Pieris napi *L.*, skg.), and the beetle Meligethes in great numbers. MacLeod (Flanders), 2 Muscids (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 392).

1271. V. montana L. (Herm. Müller, 'Alpenblumen,' pp. 470–1; Schulz, 'Beiträge,' II, pp. 100, 101–2, 192.)—This species is gynodioecious in the canton Graubünden; Schulz describes it as trimonoecious to trioecious in the Tyrol. Some

stocks bear large markedly protandrous hermaphrodite flowers; others small purely female ones. The latter possess stamens which present little external evidence of degeneration, but their anthers do not contain a single well-developed pollen-grain (Fig. 185).

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 2 beetles, 35 Diptera, 3 Hymenoptera, and a Lepidopterid. MacLeod (Pyrenees), the hover-fly Syrphus pyrastri *L.* (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 347), and Schletterer (Tyrol), the humble-bee Bombus terrester *L.*

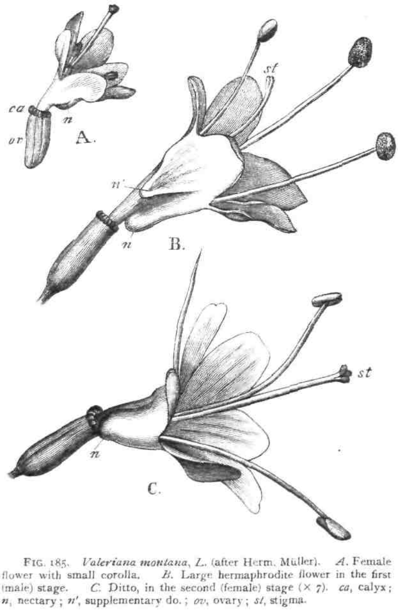


FIG. 185. *Valeriana montana*, *L.* (after Herm. Müller). *A.* Female flower with small corolla. *B.* Large hermaphrodite flower in the first (male) stage. *C.* Ditto, in the second (female) stage (× 7). *ca*, calyx; *n*, nectary; *n'*, supplementary do.; *ov*, ovary; *st*, stigma.

1272. V. saxatilis L. (Schulz, 'Beiträge,' II, pp. 102–3, 193.)—Schulz describes this species as trimonoecious to trioecious, and states that the female flowers are much smaller than the male and hermaphrodite ones.

VISITORS.—Schulz observed small and medium-sized flies.

1273. V. supina L.—Kerner states that this species is gynodioecious.

1274. V. saliunca All.—As the last species.

1275. V. tripteris L. (Herm. Müller, 'Alpenblumen,' pp. 471–3.)—This species is dioecious in the canton Graubünden; Schulz describes it as gynodioecious and androdioecious with protandrous hermaphrodite flowers in the Tyrol. Kerner states that the pseudo-hermaphrodite female flowers open (as in V. dioica) 3–5 days before the male ones. Here again there are small-flowered and large-flowered stocks. The latter are purely male, and though besides three projecting stamens their flowers possess a style, it remains within the corolla. (Fig. 186.) Massalingo says that the plants on Monte Baldo are either micrandrous female, or macrandrous hermaphrodite, as in V. montana (Boll. Soc. bot. ital., Firenze, 1896).

VISITORS.—Herm. Müller observed 17 Diptera, a beetle, a bee, and 3 Lepidoptera.

1276. **V. cordifolia** Hoeck (=Phyllactis cordifolia *Wedd.*).—Ricca describes this species as markedly protandrous (Atti Soc. ital. sc. nat., Milano, xiv, 1871).

1277. **V. capitata** Pall.—Ekstam says that the flowers of this species are 5–8 mm. in diameter in Nova Zemlia. They smell like heliotrope, and are either markedly protandrous or homogamous.

VISITORS.—These are flies, including Sarcophaga atriceps *Zett.*

1278. **V. exaltata** Mik.—

VISITORS.—Loew observed the Muscid Cynomyia mortuorum *L.* in the Berlin Botanic Garden.—

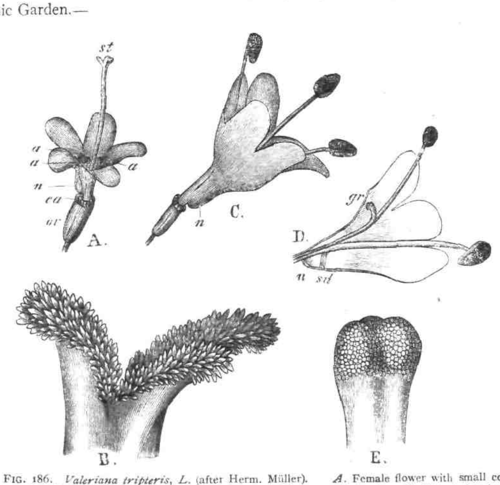


FIG. 186. *Valeriana tripteris*, *L.* (after Herm. Müller). *A.* Female flower with small corolla (× 7). *B.* Stigma of ditto (× 80). *C.* Male flower with large corolla (× 7). *D.* Ditto in longitudinal section; ovary and calyx left out (× 7). *a*, anther; *ca*, calyx; *gr*, style; *n*, nectary; *ov*, ovary; *sd*, nectar-cover; *st*, stigma.

1279. **V. alliariaefolia** Vahl.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Scarabaeidae*: 1. Cetonia aurata *L.*, dvg. the flowers. **B. Diptera.** (*a*) *Muscidae*: 2. Echinomyia fera *L.* (*b*) *Syrphidae*: 3. Eristalis tenax *L.* **C. Hymenoptera.** *Apidae*: 4. Bombus terrester *L.* ☿, skg.

1280. **V. asarifolia** Dufr.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Scatophaga merdaria *F.* (*b*) *Syrphidae*: 2. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 3. Andrena sp. ♀, skg. and

po-cltg.; 4. Osmia fulviventris *Pz.* ♂, skg. **C. Lepidoptera.** *Rhopalocera*: 5. Pieris brassicae *L.*, skg.

1281. **V. Phu** L.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Scarabaeidae*: 1. Rhizotrogus solstitialis *L.*, dvg. the flowers. **B. Diptera.** *Syrphidae*: 2. Helophilus floreus *L.* **C. Hymenoptera.** *Apidae*: 3. Osmia rufa *L.* ♀, po-cltg. **D. Lepidoptera.** *Rhopalocera*: 4. Pieris brassicae *L.*, skg.

404. Centranthus DC.

Red or white Lepidopterid flowers; markedly protandrous (Delpino, 'Ult. oss.,' p. 127); with nectar secreted in a spur at the base of the corolla-tube.

1282. **C. ruber** DC.—Schulz ('Beiträge,' II, pp. 103–4) describes the flowers of this species as zygomorphous, like those of the other Valerianeae. One corolla-lobe forms the upper lip, while the four others make up the lower one. The narrow corolla-tube, which Kerner describes as longitudinally divided into two by a thin membrane, is 8–10 mm. long, with a spur of 6–7 mm. The anther of the single stamen, which is situated right or left of the upper lip, is introrse, but during dehiscence it assumes an oblique or even horizontal position. At first the style projects but little from the corolla-tube, but after the anthers have dehisced it elongates, and protrudes 5–6 mm. beyond the corolla. Automatic self-pollination is thus prevented.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (garden plants in Helgoland), the diurnal hawk-moth Macroglossa stellatarum *L.* Loew (Bellagio), ditto. Schulz (Bozen), chiefly butterflies—1. Papilio podalirius *L.*; 2. P. machaon *L.*; 3. Parnassius apollo *L.*; 4. Pieris brassicae *L.*; 5. P. rapae *L.* Mattei (Genoa), butterflies and Zygaenidae. Loew (Berlin Botanic Garden).—**A. Coleoptera.** *Scarabaeidae*: 1. Cetonia aurata *L.*, dvg. the flowers. **B. Diptera.** *Syrphidae*: 2. Syritta pipiens *L.*, po-dvg. (?); 3. Syrphus luniger *Mg.*, casual. **C. Lepidoptera.** *Rhopalocera*: 4. Vanessa urticae *L.*, skg.

1283. **C. angustifolius** DC.—

VISITORS.—The following were observed by Loew in the Berlin Botanic Garden.

A. Coleoptera. *Scarabaeidae*: 1. Cetonia aurata *L.*, dvg. the flowers. **B. Diptera.** *Syrphidae*: 2. Eristalis sepulcralis *L.*, casual; 3. E. tenax *L.*, do. **C. Lepidoptera.** *Rhopalocera*: 4. Pieris brassicae *L.*, skg.; 5. Vanessa urticae *L.*, do.

405. Valerianella Tourn.

Flowers bluish-white in colour; homogamous or protogynous; in dense cymes, but inconspicuous owing to their small size; nectar secreted and concealed in an expansion at the base of the corolla-tube.

1284. **V. olitoria** Pollich. (Herm. Müller, 'Fertilisation,' p. 308, 'Weit. Beob.,' III, p. 98; Kirchner, 'Flora v. Stuttgart,' p. 675; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 392–3; Knuth, 'Bloemenbiol. Bijdragen'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Hermann Müller states that the corolla of the minute flowers of this species consists of a tube, the lower part of which is about

$\frac{1}{3}$ mm. long and barely $\frac{1}{4}$ mm. wide. It then suddenly expands to a diameter of about $\frac{3}{4}$ mm., and ends in a limb which is usually 5- or 6-lobed, and about 2 mm. across. In the base of the expansion tiny drops of nectar are secreted. The flowers are homogamous. Soon after they open the three stamens project straight out of the corolla, their anthers being covered with pollen all over; the simultaneously matured stigma is at a lower level, and some pollen-grains that have fallen from the anthers adhere to it. The style gradually elongates, bringing the stigma to the level of the anthers. Automatic self-pollination is therefore inevitable, but crossing may also take place as the result of insect-visits.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Lema cyanella *L.* (H. M.). (*b*) *Elateridae*: 2. Limonius cylindricus *Payk.* (H. M.). (*c*) *Nitidulidae*: 3. Meligethes, very numerous, po-dvg. (H. M.). (*d*) *Staphylinidae*: 4. Philanthus sp. (H. M.). **B. Diptera.** (*a*) *Empidae*: 5. Cyrtoma spuria *Fall.* (H. M.); 6. Empis pennipes *L.*, freq., skg. (H. M.); 7. E. trigramma *Mg.*, in large numbers, skg. (H. M.); 8. Hilara sp., do. (H. M.). (*b*) *Lonchopteridae*: 9. Lonchoptera punctum *Mg.* (H. M.). (*c*) *Muscidae*: 10. Aricia incana *Wiedem.*, freq., skg. (H. M.); 11. Lucilia sp., freq. (H. M.); 12. Onesia sepulcralis *Mg.* (H. M.); 13. Pollenia vespillo *F.*, nect-lkg. (H. M.); 14. Psila fimetaria *L.*, skg. (H. M.); 15. Scatophaga stercoraria *L.*, ♀ and ♂, in large numbers, skg. (H. M.); 16. Sepsis sp. (H. M.); 17. Siphona geniculata *Deg.*, skg. (H. M.). (*d*) *Syrphidae*: 18. Ascia podagrica *F.*, very common, skg. and po-dvg. (H. M.); 19. Syritta pipiens *L.*, do. (H. M.). (*e*) *Bibionidae*: 20. Dilophus sp. (H. M.). (*f*) *Mycetophilidae*: 21. Sciara sp. (H. M.). **C. Hemiptera.** 22. Eurydema oleraceum *L.*, skg. (H. M.). **D. Hymenoptera.** *Apidae*: all skg.: 23. Andrena albicans *Müll.* ♀ (Budd.); 24. A. collinsonana *K.* ♀ (Budd.); 25. A. convexiuscula *K.* ♀ (Budd.); 26. A. gwynana *K.* ♀ (Budd.); 27. A. nitida *Fourcr.* ♀ (Budd.); 28. A. parvula *K.* ♀ (Budd.); 29. A. Smithella *K.* ♀ (Budd.); 30. Halictus politus *Schenck*, ♀ (Budd.); 31. Nomada ruficornis *L.* (=N. signata *Jur.*) ♂ (Budd.); 32. N. sp. (Budd.); 33. Sphecodes gibbus *L.* ♂ (Budd.). **E. Lepidoptera.** (*a*) *Noctuidae*: 34. Euclidia mi *L.*, casual, skg. (H. M.). (*b*) *Rhopalocera*: 35. Polyommatus dorilis *Hfn.* (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth, the beetle Meligethes, and some flies (skg.)—1. Lucilia caesar *L.*; 2. Syritta pipiens *L.*; 3. Syrphus ribesii *L.* Alfken (Bremen), the humble-bee Bombus muscorum *F.* ♀, skg. Rössler (Wiesbaden), the Tineid moth Adela rufifrontella *Tr.*

1285. V. auricula *DC.* (=V. rimosa *Bast.* and V. dentata *Loisel*).—Kirchner states that the flower mechanism of this species agrees essentially with that of V. olitoria. Kerner describes the flowers as protogynous. Automatic self-pollination is at first excluded by downward curving of the style at the time when the anthers dehisce; but this subsequently bends upwards, and autogamy is then possible.

Visitors.—Herm. Müller only saw the small bee Halictus longulus *Sm.*, skg.

1286. V. carinata Loisel.—Kerner states that the flower mechanism of this species is similar to that of V. auricula.

1287. V. dentata Pollich (=V. Morisonii *DC.*).—Hermann Müller states the mechanism of this species is similar to that of V. olitoria. Kerner describes the flowers as protogynous.

LIV. ORDER *DIPSACEAE* DC.

LITERATURE.—Knuth, 'Grundriss d. Blütenbiol.,' pp. 63–4.

The small flowers are united into large capitula, so that they are very conspicuous and receive numerous insect-visits. Cross-pollination is secured in our native species by marked protandry of the hermaphrodite flowers. Nectar is secreted by the surface of the ovary, and is concealed in the base of the corolla-tube. All the species consequently belong to flower class **S.** *Gynodioecism is common.*

406. Morina Tourn.

Slightly protogynous flowers, which open in the twilight, and are therefore adapted to the visits of crepuscular and nocturnal Lepidoptera.

1288. M. persica L. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 351.)—Kerner states that in this species protogyny only lasts for half-an-hour, but this is sufficient to permit of crossing taking place at first. As soon as the limb of the corolla expands, the thick swollen stigma becomes visible just above the passage leading to the nectar, its receptive surface facing downwards. The two anthers behind it are still immature, so that the proboscis of an insect, if already dusted with pollen, must effect crossing while probing for nectar.

1289. M. elegans Fisch. et Avé-Lall. (=M. longifolia *Wall.*). (Hildebrand, Bot. Ztg., Leipzig, xxvii, 1869, pp. 488–91.)—Hildebrand describes the flowers of this species as homogamous, but the stigma projects beyond the anthers, so that insects usually touch it first, cross-pollination being thus favoured. The stigma subsequently bends downwards and comes into contact with the anthers, and automatic self-pollination may therefore take place at this stage.

407. Dipsacus L.

Flowers whitish or lilac in colour; markedly protandrous; aggregated into ovoid or globular heads. Spinescent bracts prevent insect visitors from creeping over the inflorescences, and these touch the anthers and stigmas with their heads, not their feet.

1290. D. sylvestris Mill. (Herm. Müller, 'Fertilisation,' pp. 308–9, 'Weit. Beob.,' III, p. 76; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892, p. 81; Knuth, 'Bloemenbiol. Bijdragen'; Loew, 'Blütenbiol. Floristik,' p. 390.)—Hermann Müller describes the corolla-tube of the lilac flowers of this species as 10–11 mm. long. In the first stage of anthesis the dehisced anthers project; in the second stage usually only one branch of the style protrudes, the other being vestigial as a rule. Hermann Müller explains this last peculiarity as an adaptation to the visits of humble-bees. When one of these thrusts its head into a flower, one branch of the style would get in the way of the other were both equally developed. A more complete pollination of the entire stigmatic surface of one branch by the head of the humble-bee is possible when the other branch is absent. Kirchner says that anthesis begins at an intermediate zone of the capitulum, and extends both inwards and outwards from this.

Kirchner mentions an interesting arrangement for securing safety from wingless insects that might creep up from the ground, i. e. the collection of rain water in the hollows formed by the union of the bases of the cauline leaves. The same arrangement is found also in D. laciniatus and D. fullonum.

Visitors.—Herm. Müller observed the following in Westphalia, all skg.—

A. Diptera. *Syrphidae*: 1. Volucella pellucens *L.* **B. Hymenoptera.** *Apidae*: 2. Bombus agrorum *F.* ♀ and ☿; 3. B. lapidarius *L.* ♀, ☿ and ♂, freq.; 4. Crocisa scutellaris *F.* ♀; 5. Halictus tetragonius *Klg.* ♂; 6. H. sexcinctus *F.* ♂; 7. Megachile lagopoda *L.* ♀ and ♂; 8. M. maritima *K.* ♀ and ♂; 9. Psithyrus rupestris *F.* ♀.

Heinsius gives the following for Holland.—

A. Diptera. *Syrphidae*: 1. Eristalis pertinax *Scop.* ♀. **B. Hymenoptera.** *Apidae*: 2. Bombus agrorum *F.* ♂; 3. B. rajellus *K.* ♂; 4. Megachile maritima *K.* ♂; 5. Psithyrus campestris *Pz.* ♂; 6. P. vestalis *Fourcr.* ♂. **C. Lepidoptera.** *Rhopalocera*: 7. Pieris rapae *L.* ♂; 8. Rhodocera rhamni *L.* ♂ and ♀; 9. Vanessa io *L.*; 10. V. urticae *L.*

The following were recorded by the observers, and for the localities stated.—

Loew (Brandenburg), the humble-bee Bombus cognatus *Steph.* ♂, skg. ('Beiträge,' p. 40). Schletterer (Tyrol), 2 humble-bees—Bombus terrester *L.* and B. arenicola *Thoms.* von Dalla Torre (Tyrol), the humble-bee Bombus muscorum *F.* ♂. MacLeod (Flanders), 3 humble-bees, a hover-fly, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 373). Knuth (Kiel Botanic Garden), 2 skg. and po-cltg. humble-bees—Bombus lapidarius *L.* ☿, and B. terrester *L.* ♀ and ☿.

1291. D. fullonum L. (Kirchner, 'Flora v. Stuttgart,' pp. 678–9.)—Kirchner describes the whitish protandrous flowers of this species as possessing a corolla 12–14 mm. long, scarcely 1 mm. thick in its lower part, but gradually expanding upwards like a funnel. Anthesis begins (as in D. sylvestris) in an intermediate zone, from which it extends upwards and downwards. After the flower has opened, the stamens with their lilac-coloured anthers project 5–6 mm. beyond the corolla. When the anthers have withered, the style (at first enclosed in the corolla) elongates, so that the stigmas are situated 2–4 mm. beyond the stamens. One of the two stigmatic branches is often vestigial.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Kirchner (Wurtemberg), humble-bees and small Nitidulids. Knuth (Kiel Botanic Garden), 2 humble-bees—Bombus lapidarius *L.* and B. terrester *L.*, skg. ('Bloemenbiol. Bijdragen'). F. F. Kohl (Tyrol), the true wasp Ancistrocerus parietum *L.*

1292. D. laciniatus L. (Kirchner, 'Beiträge,' p. 63.)—The flowers of this species are pale lilac, almost white in colour. Kirchner describes them as markedly protandrous, with a corolla about 10 mm. long, from which the diverging stamens project 5 mm. After the anthers have dropped off the style grows out of the corolla-tube, and protrudes as much as 4–5 mm. Here again one of the two stigmatic branches is usually vestigial; if both are fully formed they are recurved. Anthesis takes place as in the last two species.

408. **Cephalaria** Schrad.

1293. **C. alpina** Schrad.—

Visitors.—Loew (Berlin Botanic Garden) observed 2 humble-bees—Bombus hortorum *L.* ♀, skg., and B. terrester *L.* ☿, skg. and po-cltg.

1294. **C. radiata** Griseb. et Schenk.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. E. tenax *L.*; 3. Syrphus albostriatus *Fall.*; 4. S. balteatus *Deg.*; 5. S. ribesii *L.* **B. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.* ☿, skg. and po-cltg.; 7. Bombus hypnorum *L.* ☿, skg.; 8. Halictus cylindricus *L.* ♂, do.

1295. **C. uralensis** Roem et Schult. (=C. corniculata *Roem et Schult.*).—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus ribesii *L.*; 2. Volucella pellucens *L.*, skg. **B. Hymenoptera.** *Apidae*: 3. Bombus agrorum *F.* ♂, skg.; 4. B. terrester *L.* ♀, do.; 5. Psithyrus campestris *Pz.*, var. rossiellus *K.* ♂, do. Also on the var. *cretacea* 3 bees—1. Bombus terrester *L.* ♂, skg.; 2. Prosopis communis *Nyl.* ♀; 3. Psithyrus rupestris *F.* ♂, skg.

409. **Knautia** L.

Flowers lilac or white in colour; arranged in conspicuous flat hemispherical inflorescences, belonging to class **S.** Gynodioecious, with protandrous hermaphrodite flowers.

1296. **K. arvensis** Coult. (=Scabiosa arvensis *L.*, and Trichera arvensis *Schrad.*). (Sprengel, 'Entd. Geh.,' p. 84; Herm. Müller, 'Fertilisation,' pp. 309–13, 'Alpenblumen,' p. 399, 'Weit. Beob.,' III, pp. 76–7; Schulz, 'Beiträge,' II, pp. 173, 192; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 83–4, 156–7, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235, 'Blütenbiol. Beob. in Thüringen,' 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen,' and other memoirs; Loew, 'Blütenbiol. Floristik,' pp. 390, 394, 398.)—In this species about fifty flowers are aggregated into a head, the conspicuousness of which is increased, as Hermann Müller points out, by increase in size of the corollas towards the periphery. The corolla-tubes are 4–9 mm. long, and expand above into funnels, to an extent proportional to the size of the florets. Nectar is secreted on the upper surface of the ovary, and protected from rain by the hairs lining the corolla-tube: it is readily accessible even

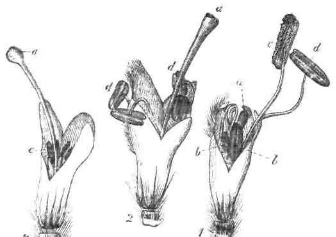


FIG. 187 *Knautia arvensis, Coult.* (after Herm. Müller). (1) Hermaphrodite flower in the first (male) stage, after removal of the corolla-lobes (× 3½). (2) Ditto, in the second (female) stage. (3) Female flower, after removal of the limb of the corolla. *a*, stigma; *b*, stamens still enclosed in the flower; *c*, ripe stamens; *d*, exhausted stamens; *e*, vestigial stamens.

to short-tongued insects. The pollen is also easily secured. In the first (male) stage the stamens of the hermaphrodite flowers project 4–5 mm. from the corolla, and the anthers turn their pollen-covered sides upwards. The stamens mature successively, so that this first stage lasts for several days. After all the stamens have completed their cycle of development, the anthers drop off and the filaments shrivel. The style, so far concealed in the mouth of the corolla, now grows to such an extent that the maturing stigma projects from the flower as far as the stamens did at first. Although the individual flowers develop centripetally, the elongation of the styles and the maturation of the stigmas only begin when all the stamens of the head have withered, so that the entire inflorescence is at first purely male, and then purely female. Insect visitors, therefore, when creeping over a capitulum either get dusted with abundant pollen or else pollinate numerous stigmas during a single visit. Automatic self-pollination is not entirely excluded, for as the styles elongate some stigmas come into contact with the anthers of their florets.

Warnstorf describes the pollen-grains (examined in water) as almost spherical, white, quite opaque, with 3 large germinating processes, up to 137 μ in diameter.

Besides stocks with hermaphrodite flowers, there are often some with female ones, especially at the beginning of the flowering season. The stamens of these are more or less reduced. The diameter of the inflorescence is usually as great as in hermaphrodite stocks, but in some female plants it is scarcely 2 cm.

MacLeod (Flanders) and Charles Darwin (Kent) noticed gynodioecism. Willis says that in Cambridgeshire female stocks are commoner than hermaphrodite ones.

Besides plants with female flowers, Lindman observed on the Dovrefjeld a variety with shorter styles, vestigial stamens, and enlarged actinomorphous corollas (var. *isantha* L. M. Neumann). This modification is apparently due to a fungus.

Visitors.—The most important one is a bee, Andrena hattorfiana *F.*, which devotes itself almost exclusively to Knautia. It is everywhere associated with this species. I observed it in Thuringia, Sylt, Föhr, Schleswig-Holstein, Mecklenburg, and also in Rügen, where I captured 6 individuals one warm forenoon.

I also observed the following in Schleswig-Holstein (S.-H.) and Rügen (R.).—

A. Coleoptera. All po-dvg.: (*a*) *Cerambycidae*: 1. Strangalia melanura *L.* (R.). (*b*) *Curculionidae*: 2. Miarus campanulae *L.* (S.-H.). (*c*) *Nitidulidae*: 3. Meligethes aeneus *F.* (S.-H.). **B. Diptera.** (*a*) *Conopidae*: 4. Sicus ferrugineus *L.*, very common, po-dvg. (R.). (*b*) *Empidae*: 5. Empis livida *L.*, po-dvg. (S.-H.); 6. E. opaca *F.* do. (S.-H.); 7. E. tessellata *F.* do. (S.-H.). (*c*) *Muscidae*: 8. Aricia incana *Wied.* po-dvg. (S.-H.); 9. Dexia canina *F.* do. (R.); 10. Small Muscids, do. (S.-H.). (*d*) *Syrphidae*: all skg. and po-dvg.: 11. Eristalis anthophorinus *Zett.* ♂ and ♀ (R.); 12. E. arbustorum *L.* (S.-H.); 13. E. horticola *Deg.* (S.-H., R.); 14. E. intricarius *L.* (S.-H., R.); 15. E. nemorum *L.* (S.-H.); 16. E. pertinax *Scop.* (S.-H.); 17. E. rupium *F.* (S.-H.); 18. E. sepulcralis *L.* (R.); 19. E. tenax *L.* (S.-H., R.); 20. Helophilus pendulus *L.* (S.-H.); 21. H. trivittatus *F.* (S.-H.); 22. Sericomyia borealis *Fall.* ♂ (R.); 23. Syritta pipiens *L.* (S.-H.); 24. Syrphus pyrastri *L.* ♀ (R.); 25. S. ribesii *L.* (S.-H.); 26. Volucella bombylans *L.* ♀ and ♂, and the var. plumata *Mg.* (R., S.-H.). (*e*) *Tabanidae*: 27. Haematopota pluvialis *L.* (R.). **C. Hemiptera.** 28. Calocoris roseomaculatus *Deg.* (S.-H.). **D. Hymenoptera.** *Apidae*: 29. Andrena gwynana *K.* (S.-H.); 30. Apis mellifica *L.* ☿, very common (S.-H., R.); 31. Bombus agrorum *F.* ☿ (S.-H., R.); 32. B. distinguendus *Mor.* (S.-H.); 33. B. hortorum *L.* (S.-H.); 34. B. lapidarius *L.* ☿ and ♀ (S.-H., R.);

35. B. pratorum *L.* (S.-H.); 36. B. rajellus *K.* (S.-H.); 37. B. terrester *L.* (S.-H.); 38. Dasypoda plumipes *Pz.* (S.-H.); 39. D. thomsoni *Schlett.* ♀ (R.); 40. Halictus fulvicornis *K.* (S.-H.); 41. Megachile centuncularis *L.* ♀ (R.); 42. Nomada armata *H.-Sch.*, one (R.); 43. Psithyrus vestalis *Fourcr.* (S.-H.). All skg., 29–42 also po-cltg. **E. Lepidoptera.** All skg.: (*a*) *Noctuidae*: 44. Plusia gamma *L.* (S.-H.). (*b*) *Rhopalocera*: 45. Argynnis aglaja *L.* (S.-H.); 46. A. ino *L.* (S.-H.); 47. A. paphia *L.*, very numerous (R.); 48. Epinephele janira *L.* (S.-H., R.); 49. Hesperis lineola *Ochs.* (S.-H.); 50. Lycaena semiargus *Rott.* (S.-H.); 51. Pieris sp. (R.); 52. Polyommatus phloeas *L.* (S.-H.); 53. Satyrus semele *L.* (S.-H.); 54. Vanessa atlanta *L.* (R.); 55. V. urticae *L.* (R., S.-H.). (*c*) *Sphingidae*: 56. Ino statices *Esp.* (R.); 57. Zygaena filipendulae *L.* (S.-H.); 58. Z. 2 sp. (R.).

I observed the following in Thuringia (' Blütenbiol. Beob. in Thüringen,' p. 38).—

A. Coleoptera. 1. Judolia cerambyciformis *Schr.*; 2. Meligethes sp.; 3. Strangalia melanura *L.*; 4. Trichius fasciatus *L.*, freq., po-dvg. **B. Diptera.** (*a*) *Empidae*: 5. Empis tessellata *L.*, skg. and po-dvg. (*b*) *Muscidae*: 6. Aricia basalis *Zett.*, freq.; 7. Homalomyia scalaris *F.*, skg. (*c*) *Syrphidae*: all skg. and po-dvg.; 8. Eristalis pertinax *Scop.* ♂; 9. Syrphus annulipes *Zett.* ♀; 10. Volucella bombylans *L.*, var. plumata *Mg.*, freq,; 11. V. pellucens *L.* **C. Hymenoptera.** *Apidae*: all skg. except 20: 12. Bombus agrorum *F.* ♀; 13. B. hypnorum *L.* ♂; 14. B. lapidarius *L.* ☿; 15. B. soroënsis *F.*, var. proteus *Gerst.* ☿; 16. B. terrester *L.* ☿; 17. Psithyrus barbutellus *K.* ♂; 18. P. quadricolor *Lep.*=P. luctuosus *Hoffer.*; 19. P. vestalis *Fourcr.* ♂, freq.; 20. Halictus cylindricus *F.* ♀, tarsi thickly covered with violet pollen. **D. Lepidoptera.** All skg.: 21. Argynnis paphia *L.*; 22. Epinephele janira *L.*; 23. Ino statices *L.*, freq.; 24. Zygaena pilosellae *Esp.*; 25. Z. trifolii *Esp.*

Alfken observed the following at Bremen.—

A. Diptera. (*a*) *Bombyliidae*: 1. Anthrax paniscus *Rossi*, very common, skg.; 2. Exoprosopis capucina *F.*, not infrequent, skg. (*b*) *Conopidae*: 3. Conops quadrifasciatus *Deg.*, not infrequent; 4. Physocephala rufipes *F.*, rare, skg.; 5. Sicus ferrugineus *L.*, very common, skg. (*c*) *Muscidae*: 6. Echinomyia tessellata *F.*, very common. (*d*) *Syrphidae*: 7. Eristalis anthrophorinus *Zett.*, rare; 8. E. arbustorum *L.*; 9. E. intricarius *L.*, ♀ and ♂, very common, skg.; 10. E. pertinax *Scop.*; 11. E. sepulcralis *L.*; 12. E. tenax *L.*, ♀ and ♂, very common, skg.; 13. Helophilus pendulus *L.*; 14. H. trivittatus *F.*; 15. Platycheirus peltatus *Mg.*; 16. Volucella bombylans *L.*; 17. V. pellucens *L.* (*e*) *Tabanidae*: 18. Tabanus rusticus *L.* **B. Hymenoptera.** (*a*) *Apidae*: 19. Andrena gwynana *K.* ♀, 2nd generation, rare, po-cltg.; 20. A. hattorfiana *F.*, freq., ♀, skg. and po-cltg., ♂ skg.; 21. A. marginata *F.*, rare, ♀ skg. and po-dvg., ♂ skg.; 22. Bombus agrorum *F.*, ☿ and ♂; 23. B. arenicola *Thoms.* ♀, ☿ and ♂; 24. B. derhamellus *K.* ♀, ☿ and ♂; 25. B. hortorum *L.* ♀, skg.; 26. B. lapidarius *L.* ♂, skg.; 27. B. lucorum *L.* ☿ and ♂; 28. B. muscorum *F.* ♀ and ♂; 29. B. pratorum *L.* ♂, skg.; 30. B. proteus *Gerst.* ♀ and ☿, freq., skg. and po-dvg., ♂ freq., skg.; 31. B. ruderatus *F.* ♂, skg.; 32. B. sylvarum *L.* ♂, skg.; 33. B. terrester *L.* ♂, very common, skg.; 34. Coelioxys acuminata *Nyl.* ♂; 35. C. conoidea *Ill.* ♀ and ♂, rare, skg.; 36. C. rufescens *Lep.* ♀, skg.; 37. Epeolus variegatus *L.* ♀, rare; 38. Eriades nigricornis *Nyl.* ♀; 39. Halictus calceatus *Scop.* ♀; 40. H. leucozonius *Schr.* ♀; 41. H. zonulus *Sm.* ♀; 42. Megachile centuncularis *L.* ♂; 43. M. circumcincta *K.* ♂; 44. Melitta leporina *Pz.* ♂; 45. Nomada armata *H.-Sch.*, very rare, skg.; 46. N. jacobaeae *Pz.* ♀ and ♂, rare, skg.; 47. Psithyrus barbutellus *K.* ♀ and ♂, not infrequent, skg.; 48. P. campestris *Pz.* ♀ and ♂, skg.; 49. P. rupestris *F.* ♀ and ♂, do.; 50. P. vestalis *Fourcr.* ♀ and ♂, do.; 51. Stelis phaeoptera *K.* (*b*) *Sphegidae*: 52. Ammophila campestris *Ltr.*, skg.; 53. A. sabulosa *L.* ♀ and ♂, freq., skg.; 54. Crabro scutellatus *Schev.*; 55. C. subterraneus *F.* ♀ and ♂, not infrequent. (*c*) *Vespidae*: 56. Odynerus oviventris *Wesm.* ♂; 57. O. parietum *L.* ♂.

Loew gives the following.—

I. For Brandenburg ('Beiträge,' p. 40).—**Hymenoptera.** (*a*) *Apidae*: 1. Andrena hattorfiana *F.* ♀, skg. (*b*) *Sphegidae*: 2. Bembex rostrata *L.* ♀, skg.; 3. Tachytes obsoletus *Rossi* ♀, skg. II. For Silesia (op. cit., p. 32).—**A. Coleoptera.** (*a*) *Cerambycidae*: 1. Leptura maculicornis *Deg.*; 2. Strangalia bifasciata *Müll.* (*b*) *Nitidulidae*: 3. Meligethes sp. (*c*) *Oedemeridae*: 4. Oedemera flavipes *L.* ♂. **B. Diptera.** (*a*) *Empidae*: 5. Empis sp. skg. (*b*) *Syrphidae*: all skg.: 6. Melithreptus scriptus *L.*; 7. Syrphus ribesii *L.*; 8. Volucella bombylans *L.*; 9. V. pellucens *L.* **C. Hymenoptera.** *Apidae*: all skg.: 10. Apis mellifica *L.* ☿; 11. Bombus agrorum *F.* ♀; 12. Macropis labiata *Pz.* ♂; 13. Megachile argentata *F.* ♂; 14. Nomada jacobaeae *Pz.* ♀; 15. Psithyrus campestris *Pz.* ♀. **D. Lepidoptera.** *Rhopalocera*: all skg.: 16. Argynnis paphia *L.*; 17. Epinephele janira *L.*; 18. Rhodocera rhamni *L.*; 19. Vanessa urticae *L.* III. Further for Silesia (op. cit., p. 26).—**A. Diptera.** *Conopidae*: all skg.: 1. Myopa fasciata *Mg.*; 2. Physocephala vittata *F.* ♂; 3. Zodion cinereum *F.* **B. Hymenoptera.** (*a*) *Apidae*: all skg.: 4. Andrena hattorfiana *F.* ♀; 5. Anthophora furcata *Pz.* ♂; 6. Apis mellifica *L.* ☿; 7. Coelioxys octodentata (*L.* Duf.) *Lep.* ♂; 8. Crocisa histrio *F.* ♂; 9. Dasypoda hirtipes *F.* ♂ and ♀, the latter also po-cltg.; 10. Halictus leucozonius *Schr.* ♀; 11. Nomada jacobaeae *Pz.* ♂; 12. Psithyrus campestris *Pz.* ♀. (*b*) *Sphegidae*: 13. Bembex rostrata *F.*, skg. **C. Lepidoptera.** *Rhopalocera*: 14. Pieris brassicae *L.*, skg. IV. For the Riesengebirge (R.) and Silesia (S.) (op. cit., p. 50).—**A. Diptera.** (*a*) *Asilidae*: 1. Dioctria flavipes *Mg.* (S.). (*b*) *Syrphidae*: 2. Syrphus nitidicollis *Mg.* (S.). **B. Hymenoptera.** *Apidae*: 3. Andrena convexiuscula *K.* ♂, skg. (S.). **C. Lepidoptera.** *Sphingidae*: 4. Zygaena achilleae *Esp.* (R.); 5. Z. minor *S.V.* (R.). V. For Switzerland (op. cit., p. 59).—2 Syrphids (Eristalis jugorum *Egg.*, and Volucella pellucens *L.*), and a moth (Zygaena lonicerae *Esp.*).

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for North and Central Germany.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *F.* (H. M.); 2. Pachyta octomaculata *F.* (H. M.); 3. Strangalia armata *Hbst.* (H. M., Siebengebirge); 4. S. atra *Laich.* (H. M., Siebengebirge); 5. S. attenuata *L.* (H. M.); 6. S. melanura *L.* (H. M.); 7. Toxotus meridianus *L.* (H. M., Siebengebirge). These beetles dvg. pollen and anthers; also, especially S. attenuata, skg. (*b*) *Chrysomelidae*: all dvg. the flowers: 8. Cryptocephalus sericeus *L.* (H. M.). (*c*) *Scarabaeidae*: 9. Hoplia philanthus *Sulz.*, rare (H. M.); 10. Trichius fasciatus *L.*, very common. (*d*) *Telephoridae*: 11. Malachius bipustulatus *L.*, dvg. the anthers (H. M.). (*e*) *Nitidulidae*: 12. Meligethes, freq., po-dvg. (H. M.). (*f*) *Phalacridae*: 13. Olibrus bicolor *F.*, po-dvg. (H. M.). **B. Diptera.** (*a*) *Conopidae*: 14. Sicus ferrugineus *L.*, numerous, skg. (H. M.). (*b*) *Empidae*: 15. Empis livida *L.*, extremely common, skg. (H. M.); 16. E. tessellata *F.*, do. (H. M.). (*c*) *Muscidae*: 17. Echinomyia tessellata *F.*, skg. (H. M.); 18. Micropalpus fulgens *Mg.*, skg. (H. M.); 19. Ocyptera cylindrica *F.*, do. (H. M.); 20. Prosena siberita *F.*, freq., skg. (H. M., Liebenau). (*d*) *Syrphidae*: all freq. and persistent, skg. and po-dvg.: 21. Eristalis arbustorum *L.* (H. M.); 22. E. intricarius *L.* (H. M.); 23. E. nemorum *L.* (H. M.); 24. E. tenax *L.* (H. M.); 25. Pipiza festiva *Mg.* (H. M., Lippstadt); 26. Rhingia rostrata *L.* (H. M.); 27. Syrphus ribesii *L.* (H. M.); 28. Volucella bombylans *L.* (H. M.); 29. V. pellucens *L.*, nect-lkg. (H. M.); 30. V. plumata *L.* (H. M.). **C. Hymenoptera.** Numbers in parentheses indicate length of proboscis in mm.: (*a*) *Apidae*: 31. Andrena gwynana *K.*, po-cltg.; 32. A. hattorfiana *F.* ♂ and ♀ (6–7), skg. and po-cltg. (H. M.); 33. Apis mellifica *L.*, ☿ (6), freq., skg., more rarely po-cltg.; 34. Bombus agrorum *F.* ♀, only skg. (H. M.); 35. B. hortorum *L.* ♂, ☿ and ♀, skg. (H. M.); 36. B. hypnorum *L.* ♂, do. (H. M.); 37. B. lapidarius *L.* ☿, do. (H. M.); 38. B. pratorum *L.* ♀, ☿ and ♂, do. (H. M.); 39. B. rajellus *K.* ♂, do. (H. M.);

40. B. sylvarum *L.* ♀ and ☿, do. (H. M.); 41. B. terrester *L.* ♀ and ♂, do. (H. M.); 42. B. tristis *Seidl.* ☿, do. (Budd.); 43. Ceratina callosa *F.* ♂, do. (Budd.); 44. C. cyanea *K.* ♀ and ♂, do. (H. M., Lippstadt); 45. Coelioxys conoidea *Ill.* ♀, do. (H. M.); 46. C. quadridentata *L.* ♂ and ♀, freq., skg. (H. M.); 47. Diphysis serratulae *Pz.* ♂ and ♀, very common, skg. (H. M.); 48. Halictus albipes *F.* ♀ (H. M.); 49. H. cylindricus *F.* ♀ and ♂ (H. M.); 50. H. leucozonius *Schr.* ♂ (H. M.); 51. H. lugubris *K.* ♀, skg. (Budd.); 52. H. malachurus *K.* ♀, do. (Budd.), and po-cltg. in the Oberpfalz; 53. H. quadricinctus *F.* ♀ (Budd.); 54. H. quadristrigatus *Ltr.* ♀ (Budd.); 55. H. sexcinctus *F.* ♀ (Budd.); 56. H. sexnotatus *K.* ♀ (H. M.); 57. H. xanthopus *K.* ♀ (Budd.), the species of Halictus both skg. and po-cltg.; 58. Heriades truncorum *L.* ♂, skg. (H. M.); 59. Megachile centuncularis *L.* ♂, do. (H. M.); 60. M. circumcincta *K.* ♀ and ♂, do. (H. M.); 61. M. maritima *K.* ♂ and ♀, in large numbers, skg. (H. M.); 62. M. willughbiella *K.* ♂, skg. (H. M.); 63. Nomada armata *H.-Sch.* ♀, do. (H. M.); 64. N. fabriciana *L.* ♀, do. (H. M.); 65. N. jacobaeae *Pz.* ♀, do. (H. M., Budd.); 66. N. lineola *Pz.* ♀ and ♂, do. (H. M.); 67. Osmia aenea *L.* ♂, do. (H. M., Budd.); 68. O. fulviventris *Pz.* ♀, po-cltg. (H. M.); 69. Prosopis signata *Pz.* ♀ and ♂, Budd.); 70. Psithyrus barbutellus *K.* ♂ and ♀, skg. (H. M.); 71. P. campestris *Pz.* ♀ and ♂, do. (H. M.); 72. P. rupestris *L.* ♀, do. (H. M.); 73. P. vestalis *Fourcr.* ♀, do. (H. M.); 74. Stelis aterrima *Pz.* ♂, do. (Budd.); 75. S. breviuscula *Nyl.* ♂, do. (H. M.). (*b*) *Ichneumonidae*: 76. One small sp., creeping far into the flowers (Budd.). (*c*) *Sphegidae*: 77. Bembex rostrata *L.* skg. (H. M.); 78. Mimesa bicolor *Jur.* ♂ (Budd.); 79. Philanthus triangulum *F.* ♂, skg. (Budd.); 80. Psammophila affinis *K.* ♀, do. (H. M.); 81. P. viatica *Deg.* ♂, do. (H. M.). (*d*) *Vespidae*: 82. Odynerus parietum *L.* ♀, skg. (H. M.). **D. Lepidoptera.** (*a*) *Microlepidoptera*: 83. Nemotois scabiosellus *Scop.* ♀ (Budd.). (*b*) *Noctuidae*: 84. Euclidia glyphica *L.* (H. M.); 85. Mamestra serena *S.V.* ♀ (Thuringia). (*c*) *Rhopalocera*: 86. Argynnis latonia *L.*, skg. (H. M., Oberpfalz); 87. A. niobe *L.*, do. (H. M., Oberpfalz); 88. Colias hyale *L.*, freq. (H. M., Thuringia); 89. Hesperia comma *L.*, skg. (H. M., Fichtelgebirge; Budd., Lausitz); 90. H. lineola *Ochs.* (H. M.); 91. Papilio machaon *L.* (Budd.); 92. Pieris napi *L.*, skg. (Liebenau); 93. Epinephele janira *L.* (H. M.); 94. Erebia aethiops *Esp.* (H. M.); 95. Vanessa urticae *L.* (*d*) *Sphingidae*: 96. Ino statices *L.*; 97. Zygaena carniolica *Scop.*; 98. Z. filipendulae *L.*; 99. Z. minos *S.V.*; Buddeberg says that these Zygaenae are almost entirely limited to this species and Carduus crispus; 100. Z. lonicerae *Esp.*, freq. (H. M., Thuringia). (*e*) *Tineidae*: 101. Adela sp., very common, sometimes as many as 4 on a head.

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 4 beetles, 9 flies, 10 Hymenoptera (including Andrena hattorfiana *F.*), and 23 Lepidoptera ('Alpenblumen,' pp. 399–400). Wüstnei, 2 bees—Andrena hattorfiana *F.* (Alsen, Eutin, Husum), and Nomada armata *H.-Sch.* (Alsen). Schmiedeknecht (Thuringia),—**Hymenoptera.** *Apidae*: 1. Andrena hattorfiana *F.*; 2. Bombus derhamellus *K.* ♂; 3. B. pratorum *L.* ♂; 4. Psithyrus barbutellus *K.* ♂; 5. P. globosus *Ev.* ♀; 6. P. quadricolor *Lep.* ♂; 7. Nomada armata *H.-Sch.* Hoffer (Steiermark), the cuckoo-bee Psithyrus barbutellus *K.* ♂. Schletterer (Tyrol), the bees Andrena marginata *F.* and Eucera cinerea *Lep.* Friese in Alsace (A.), Baden (B.), Hungary (H.), and Mecklenburg (M.), the following bees.—1. Andrena hattorfiana *F.* (A., B., M.); 2. A. marginata *F.* (M.); 3. Coelioxys acuminata *Nyl.*, not rare (M.); 4. C. conoidea *Ill.* (H., M.); 5. C. mandibularis *Nyl.*, rare (M.); 6. Dasypoda argentata *Pz.*, occasional (M.); 7. D. Thomsoni *Schlett.* ♂ occasional, ♀ very rare (M.); 8. Nomada armata *H.-Sch.*, occasional (M.); 9. Stelis aterrima *Pz.*, one ♀ (A.); 10. Eucera pollinosa *Lep.*, several (H.). H. de Vries (Netherlands), a bee (Halictus cylindricus *F.* ♀), and a humble-bee (Bombus agrorum *F.* ♂) (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875). MacLeod (Pyrenees), 4 humble-bees, 4 Lepidopterids, and 4 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 347). Saunders (S.)

and Smith (Sm.) (England), 5 bees:—1. Andrena hattorfiana *F.* (S., Sm.); 2. A. marginata *F.* (S., Sm.); 3. Nomada armata *H.-Sch.* (Sm.); 4. N. jacobeae *Pz.* (Sm.); 5. Osmia spinulosa *K.* (Sm.). Marquard (extreme W. of Cornwall), the bee Andrena hattorfiana *F.*

1297. K. sylvatica Duby (=Scabiosa sylvatica *L.*; and Trichera sylvatica *Schrad.*).—Kirchner ('Flora v. Stuttgart,' p. 680) says that the mechanism of the reddish-blue flowers of this species entirely agrees with that of K. arvensis, but female stocks are very rare.

VISITORS.—The following are recorded by the authorities, and for the localities stated.—

Loew (Steiermark) ('Beiträge,' p. 50).—**A. Diptera.** (*a*) *Conopidae*: 1. Occemyia atra *F.*, skg.; 2. Sicus ferrugineus *L.*, do. (*b*) *Syrphidae*: 3. Cheilosia personata *Loew.*; 4. Rhingia rostrata *Mg.*, skg. **B. Hymenoptera.** *Apidae*: 5. Andrena hattorfiana *F.* ♀, po-cltg.; 6. Ceratina cyanea *K.* ♀, skg.; 7. Halictus zonulus *Sm.* ♀, po-cltg.; 8. Psithyrus barbutellus *K.* ♀, skg.: also (Switzerland), the bee Physocephala rufipes *F.* (op. cit., p. 59). Ricca, chiefly Lepidoptera (Atti Soc. ital. sc. nat., Milano, xiv, 1871). Kirchner, chiefly beetles, bees, and Lepidoptera. Herm. Müller (Alps), 3 bees, 2 flies, 3 Lepidoptera, and a beetle ('Alpenblumen,' p. 400).

410. Succisa Neck.

Gynodioecious, with protandrous hermaphrodite florets; blue in colour, rarely white; aggregated into hemispherical heads; belonging to class **S.**

1298. S. pratensis Moench (=Scabiosa succisa *L.*). (Sprengel, 'Entd. Geh.,' p. 84; Herm. Müller, 'Fertilisation,' pp. 313–14, 'Weit. Beob.,' III, p. 77; Magnus, Sitzber. Ges. natf. Freunde, Berlin, 1881; Schulz, 'Beiträge,' II, p. 192; Knuth, 'Bl.

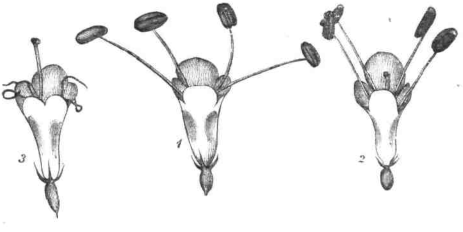


FIG. 188. *Succisa pratensis, Moench.* (after Herm. Müller). (1) Flower before the anthers have dehisced (after removal of the involucel). (2) Ditto, after the anthers have dehisced. (3) Ditto, in the female stage.

u. Insekt. a. d. nordfr. Ins.,' pp. 84, 157, 'Bloemenbiol. Bijdragen,' p. 31 (43), 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235.)—In this species, according to Hermann Müller, 50–80 tolerably similar florets are aggregated into a hemispherical head. Nectar is secreted on the surface of the ovary (as in all Dipsaceae, and is sheltered in the smooth narrow base of the corolla-tube ($\frac{3}{4}$ mm. long), which is lined with hairs above and expands upwards to a diameter of 2 mm. The outermost of the four (rarely five) corolla-lobes is the largest.

The stamens are curved inwards in the bud, but when the floret opens they extend one after the other, and their anthers dehisce, while the style has so far attained to scarcely half its length. When the anthers have withered, the style elongates to its full length, and the stigma becomes receptive. Automatic self-pollination is consequently impossible.

Besides stocks bearing hermaphrodite florets, there are also somewhat smaller female ones. Such florets possess stamens reduced to a greatly varying extent, and they are not infrequently double. In some localities female stocks are rare; elsewhere they are commoner; Magnus says they number about 10 % at Homburg, while Schulz states that they may even reach about 30 % at Brunswick and Halle. Turner (Nature, London, xl, 1889) says the florets are trimorphous. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes the pollen-grains as very large, white, spherical, adherent owing to the presence of short spinose tubercles, up to 93 μ in diameter.

VISITORS.—Herm. Müller (H. M.) and myself (Kn.) observed the following in North and Central Germany.—

A. Coleoptera. *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, gnawing the florets (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 2. Exoprosopa capucina *F.*, freq. in July (H. M.). (*b*) *Empidae*: 3. Empis livida *L.*, very numerous, skg. (H. M.). (*c*) *Muscidae*: 4. Lucilia species (H. M.); 5. L. cornicina *F.* (H. M.). (*d*) *Syrphidae*: 6. Eristalis arbustorum *L.*, freq., skg. and po-dvg. (Kn., H. M.); 7. E. intricarius *L.* (H. M.); 8. E. nemorum *L.*, freq., skg. and po-dvg. (H. M.); 9. E. tenax *L.*, do. (Kn., H. M.); 10. Helophilus pendulus *L.*, do. (Kn., H. M.); 11. Rhingia rostrata *L.*, skg. (Kn., H. M.); 12. Syrphus balteatus *Deg.*, po-dvg. (Kn.); 13. S. pyrastri *L.*, skg. and po-dvg. (H. M.); 14. S. ribesii *L.*, do. (Kn.); 15. Volucella plumata *Mg.*, skg. (H. M.). **C. Hymenoptera.** *Apidae*: 16. Andrena cetii *Schr.* ♀, po-dvg. (H. M.); 17. A. convexiuscula *K.* ♂ (H. M.); 18. Apis mellifica *L.* ☿, freq., skg. and po-dvg. (H. M., Kn.); 19. Bombus agrorum *F.* ☿ and ♂, very common, skg. (H. M.); 20. B. lapidarius *L.* ☿ and ♂, do. (Kn., H. M.); 21. B. muscorum *F.* ☿ and ♂, do. (H. M.); 22. B. pratorum *L.*, do. (H. M.); 23. B. sylvarum *L.* ♀, ☿ and ♂, do. (H. M.); 24. B. terrester *L.* ☿ and ♂, do. (H. M.); 25. Halictus cylindricus *F.* ♂, in large numbers (H. M.); 26. H. leucozonius *Schr.* ♂, do. (H. M.); 27. H. rubicundus *Chr.* ♀, po-cltg. (H. M.); 28. H. zonulus *Sm.* ♀, skg. (H. M.); 29. Psithyrus rupestris *L.* ♂, do. (H. M.); 30. P. vestâlis *Fourcr.* ♀ and ♂, do. (H. M.). **D. Lepidoptera.** (*a*) *Pyralidae*: 31. Botys purpuralis *L.*, skg. (H. M.). (*b*) *Noctuidae*: 32. Plusia gamma *L.*, freq., skg. (Kn., H. M.). (*c*) *Rhopalocera*: 33. Epinephele janira *L.*, skg. (Kn., H. M.); 34. Pieris brassicae *L.*, do. (Kn.); 35. P. rapae *L.*, numerous, skg. (Kn., H. M.); 36. Polyommatus phlaeas *L.*, do. (H. M.). (*d*) *Sphingidae*: 37. Zygaena filipendulae *L.*, very common, skg. (Kn.).

Alfken and Höppner (H.) record the following for Bremen.—

A. Hymenoptera. *Apidae*: 1. Andrena marginata *F.* ♀ and ♂; 2. Bombus agrorum *F.* ♀, ☿ and ♂; 3. B. arenicola *Ths.* ♀, ☿ and ♂; 4. B. derhamellus *K.* ♀, ☿ and ♂, skg.; 5. B. hortorum *L.*, var. nigricans, *Schmiedekn.* ☿; 6. B. jonellus *K.* ☿ and ♂; 7. B. lapidarius *L.* ♀, ☿ and ♂; 8. B. terrester *L.* ☿ and ♂; 9. B. lucorum *L.* ♀; 10. B. proteus *Gerst.* ♀, ☿ and ♂; 11. B. muscorum *F.* ♀, ♂ and ☿; 12. B. sylvarum *L.* ☿ and ♂; 13. B. variabilis *Schmiedekn.* ♀, ☿ and ♂; 14. Halictus calceatus *Scop.* ♀ and ♂; 15. H. leucopus *K.* ♀ and ♂; 16. H. leucozonius *K.* ♂; 17. H. rubicundus *Chr.* ♀; 18. H. zonulus *Sm.* ♀ and ♂; 19. Psithyrus barbutellus *K.* ♀ and ♂; 20. P. campestris *Pz.* ♀ and ♂; 21. P. rupestris *F.* ♀ and ♂; 22. P. vestalis *Fourcr.* ♀ and ♂. **B. Diptera.** *Syrphidae*: 23. Arctophila mussitans *F.* ♀ and ♂, very common, skg. (H.); 24. Eristalis tenax *L.*

Willis records the following for the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp., skg.; 2. Mydaea sp., do. (*b*) *Syrphidae*: 3. Eristalis intricarius *L.*, skg.; 4. E. tenax *L.*, do.; 5. Helophilus pendulus *L.*, do.; 6. Melanostoma scalare *F.*, freq., po-dvg.; 7. Syrphus balteatus *Deg.*, skg. and po-dvg. **B. Hymenoptera.** *Apidae*: 8. Bombus agrorum *F.*, freq., skg.; 9. B. pratorum *L.*, do.; 10. B. terrester *L.*, do.; 11. Halictus cylindricus *F.*, do.; 12. H. rubicundus *Chr.*, skg.; 13. Psithyrus campestris *Pz.*, do. **C. Lepidoptera.** *Rhopalocera*: 14. Pieris napi *L.*, skg.

Burkill saw the following on the east coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Crepidodera ferruginea *Scop.*, skg. (*b*) *Nitidulidae*: 2. Meligethes picipes *Sturm*, skg.; 3. M. viridescens *F.*, do. **B. Diptera.** (*a*) *Muscidae*: 4. Anthomyia brevicornis *Zett.*, skg.; 5. A. radicum *L.*, po-dvg.; 6. Calliphora erythrocephala *Mg.*, skg.; 7. Lucilia cornicina *F.*, do.; 8. Scatophaga stercoraria *Mg.*, do.; 9. Siphona geniculata *Deg.*, do. (*b*) *Syrphidae*: 10. Eristalis tenax *L.*, skg.; 11. Melanostoma scalare *F.*; 12. Platycheirus manicatus *Mg.*; 13. Sphaerophoria scripta *L.*; 14. Syrphus balteatus *Deg.*; 15. S. ribesii *L.*, skg. **C. Hymenoptera.** (*a*) *Apidae*: 16. Bombus agrorum *F.*, very common, skg. and po-cltg.; 17. B. hortorum *L.*, skg.; 18. B. lapidarius *L.*, skg. and po-cltg. (*b*) *Formicidae*: 19. Myrmica rubra *L.*, skg. **D. Lepidoptera.** *Noctuidae*: 20. Plusia gamma *L.*, skg.

Burkill and Willis record the following for Mid-Wales ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes viridescens *F.*, freq. **B. Diptera.** (*a*) *Empidae*: 2. Pachymeria palparis *Egg.*; 3. Rhamphomyia sp., po-dvg. (*b*) *Muscidae*: 4. Anthomyia sp., skg.; 5. Hyetodisia incana *Wied.*, freq.; 6. Hylemyia lasciva *Zett.*; 7. H. strigosa *F.*, freq.; 8. Lucilia cornicina *F.*, po-dvg.; 9. Scatophaga stercoraria *L.*, skg.; 10. Siphona geniculata *Deg.*, do.; 11. Trichophticus cunctans *Mg.*, freq. (*c*) *Syrphidae*: 12. Eristalis horticola *Deg.*, skg.; 13. E. intricarius *L.*; 14. E. pertinax *Scop.*, skg.; 15. E. rupium *F.*, do.; 16. E. tenax *L.*, very common, skg.; 17. Helophilus pendulus *L.*, skg.; 18. Melanostoma scalare *F.*; 19. Platycheirus manicatus *Mg.*, skg.; 20. Sericomyia borealis *Fall.*, do.; 21. Volucella pellucens *L.*, do. **C. Hymenoptera.** *Apidae*: 22. Bombus agrorum *L.*, freq., skg.; 23. B. hortorum *L.*, skg.; 24. B. lapidarius *L.*, freq., skg.; 25. B. pratorum *L.*, skg.; 26. B. scrimshiranus *Kirby*, do.; 27. B. terrester *L.*, do. **D. Lepidoptera.** (*a*) *Noctuidae*: 28. Charaeas graminis *L.*, skg.; 29. Luperina haworthii *Curt.*, do.; 30. Plusia gamma *L.*, do. (*b*) *Rhopalocera*: all skg.: 31. Coenonympha pamphilus *L.*; 32. Lycaena icarus *Rott.*; 33. Pieris rapae *L.*; 34. Polyommatus phlaeas *L.*; 35. Vanessa atalanta *L.*; 36. V. c-album *L.*; 37. V. urticae *L.*, freq. **E. Thysanoptera.** 38. Thrips sp., freq.

The following were recorded by the observers and for the localities stated.—

Sickmann (Osnabrück), the fossorial wasp Gorytes quadrifasciatus *F.* ♀. Friese for Hungary (H.) and Mecklenburg (M.), the following bees:—1. Andrena bimaculata *K.*, 2nd generation (M.); 2. A. marginata *F.* (M.) (according to Konow); 3. A. nigriceps *K.*, very rare (M.); 4. Epeolus variegatus *L.*, occasional (M.); 5. Nomada jacobaeae *Pz.*, not infrequent (M.); 6. N. roberjeotiana *Pz.*, do. (M.); 7. N. solidaginis *Pz.*, do. (M.); 8. Prosopis dilatata *K.*, not rare (H.), occasional (M.). Rössler (Wiesbaden), 2 Tineids (Nemotois cupriacellus *Hbn.*, and N. minimellus *Zett.*). Handlirsch, the fossorial wasp Gorytes quadrifasciatus *F.* MacLeod (Flanders), 3 long-tongued and 3 short-tongued bees, a Vespid, 9 hover-flies, a Muscid, and 6 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 395–6). H. de Vries (Netherlands), 3 humble-bees—1. Bombus agrorum *F.* ☿; 2. B. lapidarius *L.* ☿;

3. B. subterraneus *L.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. ser., 2. deel, 1875). Heinsius (Holland).—**A. Hymenoptera.** *Apidae*: 1. Bombus rajellus *K.* ♂. **B. Lepidoptera.** (*a*) *Rhopalocera*: 2. Epinephele janira *L.* ♀; 3. Pieris napi *L.* ♂; 4. Polyommatus dorilis *Hfn.* ♂ and ♀. (*b*) *Sphingidae*: 5. Zygaena filipendulae *L.* ♂ and ♀, freq.; 6. Z. trifolii *Esp.*

1299. **S. australis** Reichb.—

Visitors.—Loew observed a Muscid (Echinomyia fera *L.*) and a Syrphid (Eristalis tenax *L.*) in the Berlin Botanic Garden.

411. Scabiosa L.

Flowers lilac, reddish, white, or rarely yellow in colour; aggregated into conspicuous heads: belonging to class **S.** Stocks gynodioecious, with protandrous hermaphrodite flowers.

1300. **S. Columbaria** L. (Sprengel, 'Entd. Geh.,' pp. 82–4; Herm. Müller, 'Fertilisation,' p. 315, 'Alpenblumen,' pp. 400–1; Knuth, 'Bloemenbiol. Bijdragen.')—Ludwig observed gynomonoecism more frequently than gynodioecism in this species. Sprengel has given an admirable account of the mechanism of the protandrous hermaphrodite flowers. It agrees with that of Knautia arvensis, except that there are 5 instead of 4 corolla-lobes. Each head contains 70–80 florets, those of the ray being large and zygomorphous. Sprengel, in describing this species, makes special reference to the oecological significance of these large marginal florets. Hermann Müller measured the florets, and found that the marginal ones possess corolla-tubes 6 mm. long, with throats 2–2½ mm. broad, the outer corolla-lobes being 7–8 mm. long, the lateral ones 6 mm., and the inner ones 2–3 mm. Next to these ray-florets come disk-florets with corolla-tubes 5 mm. long and throats 2 mm. broad, their lobes being only 3 mm., 2 mm., and 1½ mm., in length respectively. The central florets of the head possess corolla-tubes only 4 mm. long and 1½ mm. broad, with lobes 1½ mm. in length. Hermann Müller adds that, owing to the small size of these, and the slight increase in size from the middle to the periphery of the head, there is room for a much larger number of florets in the same area in this species than in Knautia arvensis.

The female flowers, which are most numerous at the beginning of the flowering season, also agree with those of Knautia arvensis, but they appear to occur only in certain localities, for Hermann Müller never found them at Lippstadt, where, however, the plant is scarce.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel Botanic Garden).—**A. Hymenoptera.** *Apidae*: 1. Apis mellifica *L.* ☿, skg. and po-cltg.; 2. Bombus agrorum *F.* ♀, do.; 3. B. lapidarius *L.*, do. **B. Diptera.** *Syrphidae*: 4. Rhingia rostrata *L.*, skg. and po-cltg. **C. Lepidoptera.** *Rhopalocera*: all skg.: 5. Vanessa atalanta *L.*; 6. V. io *L.*; 7. V. urticae *L.* Herm. Müller (Alps), 6 Diptera, 7 Hymenoptera, 27 Lepidoptera; and (Westphalia) the following:—**A. Diptera.** (*a*) *Conopidae*: 1. Sicus ferrugineus *L.*, skg. (*b*) *Syrphidae*: 2. Eristalis nemorum *L.*, freq., skg. and po-dvg.; 3. E. tenax *L.*, do.; 4. Helophilus trivittatus *F.*, do. **B. Hymenoptera.** 5. Apis mellifica *L.* ☿, freq., skg.; 6. Bombus lapidarius *L.*, ♂, very numerous, skg. Loew (Brandenburg) ('Beiträge,' p. 40), 2 bees (Andrena schencki *Mor.* ♀, po-cltg.; and Halictus sexcinctus *F.* ♂, skg.); also (Berlin Botanic Garden).—**A. Diptera.** *Syrphidae*: 1. Helophilus floreus *L.*; 2. H. tri-

vittatus *F.*; 3. Syrphus ribesii *L.* **B. Hymenoptera.** *Apidae*: 4. Bombus agrorum *F.* ♂, skg.; 5. B. pratorum *L.* ♀, do. **C. Lepidoptera.** *Rhopalocera*: 6. Argynnis latonia *L.*, skg.: 7. Colias rhamni *L.*, do. Wüstnei (Holstein), the bee Andrena cetii *Schr.* Schmiedeknecht (Thuringia), 3 bees—1. Andrena cetii *Schr.* (=A. marginata *F.*); 2. Nomada brevicornis *Mocs.*; 3. Psithyrus barbutella *K.* ♂. Schenck (Nassau), the bee Andrena marginata *F.* Schletterer and von Dalla Torre (Tyrol) 4 bees—1. Bombus mesomelas *Gerst.* ♂; 2. B. soroënsis *F.* ♂; 3. Podalirius parietinus *F.*; 4. Psithyrus campestris *Pz.* ♀. Frey (Zürich), the Tineid Nemotois minimellus *Zett.* MacLeod (Pyrenees), 11 Hymenoptera (including Andrena hattorfiana *F.*), 20 Lepidoptera, 4 beetles, and 13 Diptera (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 347–440).

1301. **S. ochroleuca** L. (as a species).—Schulz ('Beiträge,' II, p. 192) describes this yellow-flowered variety of S. columbaria as gynomonoecious with protandrous hermaphrodite flowers. Comes ('Ult. stud.') also speaks of the flowers as protandrous and self-fertile.

Visitors.—The following were recorded by the observers and for the localities stated.—

Friese (Hungary) (on the authority of Mocsary), 3 bees—1. Dasypoda argentata *Pz.*, and the var. braccata *Ev.*, not infreq.; 2. Eucera pollinosa *Lep.*, freq.; 3. E. scabiosae *Mocs.*: also (Thuringia) the bee Cilissa haemorrhoidalis *F.* Loew (Steiermark), 2 bees—1. Andrena cetii *Schr.* ♀, po-cltg.; 2. Halictus cylindricus *F.* ♀, skg.: also (Berlin Botanic Garden).—**A. Diptera.** *Syrphidae*: 1. Eristalis intricarius *L.*; 2. E. nemorum *L.*; 3. E. tenax *L.*; 4. Pipiza festiva *Mg.*; 5. Syrphus balteatus *Deg.*; 6. S. ribesii *L.*; 7. Volucella pellucens *L.*, skg. **B. Hymenoptera.** *Apidae*: 8. Apis mellifica *L.* ☿, skg. **C. Lepidoptera.** (*a*) *Noctuidae*: 2. Plusia gamma *L.*, skg. (*b*) *Rhopalocera*: 10. Pieris brassicae *L.*, skg.; 11. P. rapae *L.*, do.

1302. **S. suaveolens** Desf.—Schulz ('Beiträge,' I, pp. 67–8, II, p. 192) states that this species is gynomonoecious, much more rarely gynodioecious, with markedly protandrous hermaphrodite flowers. At first the strongly zygomorphous florets of the two outer circlets come into bloom. Next come the innermost florets of the head, and lastly those of the intermediate zone. Schulz asserts that the species is very injuriously affected by this way of flowering, for in many cases the stigmas of the two outer circlets of florets fully develop before the anthers of the next circlet have dehisced. And as the stigmas and anthers of the florets of two adjacent circlets are very close together, pollination of the outer by the inner ones, sometimes by means of insects, is easily possible.

Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) states that plants growing on sterile sandy ground under pine-trees near the Altruppin shooting-box, bear either only protandrous hermaphrodite florets, or else some of the zygomorphous marginal ones are female by degeneration of the anthers. This species is therefore gynomonoecious in the locality mentioned. The anthers are introrse, but during dehiscence they turn through an angle of 90°, lying horizontally at the end of the long filaments which project far out of the florets. The pollen consequently faces upwards. The pollen-grains are white, tuberculated, spheroidal or ellipsoidal, as much as 112 μ long and 88 μ broad.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Loew (Berlin Botanic Garden), the Muscid Echinomyia fera *L.* Krieger (Leipzig), 4 bees—1. Andrena marginata *F.* (=A. cetii *Schr.*); 2. Nomada jacobaeae *Pz.*; 3. N. roberjeotiana *Pz.*; 4. N. solidaginis *Pz.*

1303. **S. lucida** Vill.—According to Schulz ('Beiträge,' I, p. 65, II, p. 192), this species agrees with the last as regards the protandry of the hermaphrodite flowers, gynomonoecism, and the course of anthesis.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 4 Lepidoptera and a hover-fly ('Alpenblumen,' p. 401). Loew (Berlin Botanic Garden).—**A. Diptera.** *Syrphidae*: 1. Helophilus pendulus *L.* **B. Hymenoptera.** *Apidae*: 2. Bombus agrorum *F.* ♂, skg.; 3. B. lapidarius *L.* ♂, do.; 4. Heriades truncorum *L.* ♂, po-cltg. **C. Lepidoptera.** *Rhopalocera*: 5. Argynnis aglaja *L.*

1304. **S. gramuntia** L.—Schulz describes this species as being gynomonoecious with protandrous hermaphrodite flowers at Bozen ('Beiträge,' II, p. 192).

Visitors.—Schletterer (Pola) saw the bee Halictus calceatus *Scop.*

1305. **S. Dallaportae** Heldr.—

Visitors—Loew observed a hover-fly (Helophilus trivittatus *F.*), a bee (Apis mellifica *L.* ☿, skg.), and a butterfly (Rhodocera rhamni *L.*, skg.), in the Berlin Botanic Garden.

1306. **S. daucoides** Desf.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis aeneus *Scop.*; 2. E. intricarius *L.*; 3. Helophilus trivittatus *F.*; 4. Pipiza festiva *Mg.* **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, skg.; 6. Bombus lapidarius *L.* ♂, do.; 7. B. terrester *L.* ♂, do.; 8. Stelis aterrima *Pz.* ♀, do. **C. Lepidoptera.** *Rhopalocera*: 9. Pieris brassicae *L.*, skg.; 10. Vanessa urticae *L.*, do.

1307. **S. Hladnikiana** Host.—

Visitors.—Loew observed 2 hover-flies (Syrphus balteatus *Deg.*, and Volucella pellucens *L.*, skg.), and a butterfly (Pieris brassicae *L.*, skg.), in the Berlin Botanic Garden.

1308. **S. ucranica** L.—

Visitors.—Loew saw a hover-fly (Syrphus corollae *F.*) in the Berlin Botanic Garden.

1309. **S. atropurpurea** L. (= S. maritima *L.*).—

Visitors.—Plateau (Belgium) observed bees (Apis, Bombus hypnorum *L.*, Megachile ericetorum *Lep.*), hover-flies (Eristalis tenax *L.*, Syrphus sp.), and butterflies (Vanessa c-album *L.*, Pieris napi *L.*). These insects visited with about equal frequency the purple, red, rose-coloured, and white capitula.—For the butterflies,—Vanessa io *L.*, Pieris brassicae *L.*, and P. napi *L.*, this also applied to the larger capitula (4–5 cm. diameter) of a sub-species.

LV. ORDER *COMPOSITAE* Adans.

Sprengel long ago called attention to the advantageous oecological peculiarities of the Compositae ('Entd. Geh.,' p. 365). Even before his time, Kölreuter had

observed the sensitiveness of the filaments of certain species (of Centaurea, Onopordon, Cichorium, and Hieracium) ('3. Fortsetzung,' p. 199, Leipzig, 1766). Hildebrand[1] has made the mechanism of the style the subject of a thorough investigation ('Ü. d. Geschlechtsverhältn. b. d. Compositen,' Nova Acta Leop., Halle, 1869). Delpino in 1870 discussed the oecological peculiarities of the

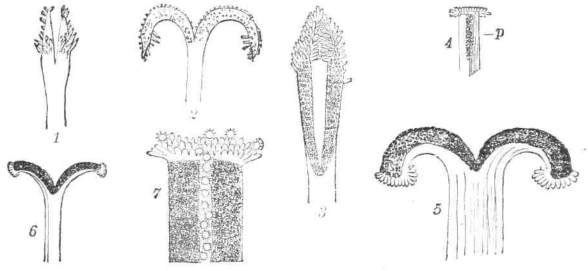


FIG. 189. *Styles and Stigmas of Compositae* (from nature). (1) Enlarged tip of the style of Bidens, with branches still almost apposed; on the outside are prominent sweeping-hairs, which diminish in size towards the apex. (2) Ditto, with the branches of the style spread out; their inner surface is closely beset with stigmatic papillae. (3) Enlarged tip of the style of Aster, still closed. The conical apex is densely beset with prominent sweeping-hairs, and below these are seen the stigmatic papillae. (4) Enlarged tip of the style of a disk-floret of Chrysanthemum segetum *L.*, in the first (male) stage. (5) Ditto, in the second (female) stage, greatly enlarged. (6) Enlarged tip of the style of a ray-floret of the same plant, with diverging stigmatic branches. (7) Tip of the style of a disk-floret of the same plant, seen from within: in the centre is a stylar groove filled with pollen-grains: greatly enlarged.

flowers of Compositae, and Hermann Müller in 1873 gave a review of the order as regards pollination mechanisms ('Fertilisation,' pp. 315–18).

The many small flowers are aggregated into a head, which is closely

[1] He here deals with the following species.—Taraxacum officinale (pp. 7 et seq., Taf. I, Figs. 1–7); Cichorium intybus (Taf. I, Figs. 8–10); Vernonia scaberrima (p. 14); Cacalia sonchifolia (p. 15, Taf. I, Figs. 11–13); Eupatorium riparium and E. cannabinum (pp. 16–17, Taf. I, Figs. 14–19); Liatris spicata (pp. 17–19, Taf. I, Figs. 20–5); Dahlia variabilis (pp. 19–20, Taf. I, Figs. 26–9); Bidens tripartita (Taf. I, Figs. 30–1); Agathaea coelestis (pp. 20–1, Taf. II, Figs. 1–6); Solidago virgaurea (pp. 22–3, Taf. II, Figs. 7–10); Bellis perennis (pp. 23–4, Taf. II, Figs. 11–15); Telekia speciosa (pp. 24–5, Taf. II, Figs. 16–17); Doronicum macrophyllum (pp. 25–6, Taf. II, Figs. 18–28); Senecio populifolius (pp. 27–8, Taf. II, Figs. 29–36); Gaillardia lanceolata (pp. 28–9, Taf. III, Figs. 1–3); Silphium doronicifolium (pp. 29–31, Taf. III, Figs. 4–9); Calendula arvensis (pp. 31–3, Taf. III, Figs. 10–17); C. officinalis (p. 33, Taf. III, Figs. 18–20); Melampodium divaricatum (pp. 33–4, Taf. III, Figs. 21–5); Madaria elegans (pp. 34–5, Taf. IV, Figs. 26–7); Petasites officinalis (pp. 35–40, Taf. IV, Figs. 1–19); Gnaphalium dioicium (pp. 40–2, Taf. III, Figs. 26–32); Gazania rigens and G. speciosa (pp. 42–4, Taf. IV, Figs. 20–5); Cryptostemma hypochondriacum (pp. 44–5, Taf. VI, Figs. 23–5); Arctotis acaulis (p. 45, Taf. VI, Figs. 21–2); Lappa minor and other sp. (p. 46, Taf. V, Fig. 32); Echinops sphaerocephalus (pp. 46–8, Taf. VI, Figs. 1–3); Xeranthemum annuum (pp. 48–50, Taf. V, Figs. 24–30); Centaurea montana (pp. 50–6, Taf. V, Figs. 1–23); C. scabiosa (pp. 56–7); C. dealbata (pp. 59–60, Taf. VI, Figs. 6–9); Cnicus benedictus (pp. 57–8, Taf. V, Fig. 31); Amberoa Lippii (Taf. VI, Fig. 4–5); Jurinea alata (pp. 58–9); Silybum Marianum (pp. 60–2, Taf. VI, Figs. 10–20).

surrounded in the bud by an involucre, usually made up of several series of bracts. This subsequently serves as an adequate protection against creeping animals, as well as to hold the inflorescence together. The whole is rendered conspicuous by the crowding of the flowers, the effect being heightened by outward curving of all the corollas, or by the production of the limb of each into a long outer lobe. Finally, as in most cases, the marginal flowers have lost their stamens, and even their pistils as well, being converted into long radiating tongues that greatly add to the size of the head. These ray-florets are often of a different colour from the disk-florets, so as to still further increase the conspicuousness of the inflorescences. In a few cases (Carlina) the inner bracts assume this function.

Another result of crowding is that numerous flowers of the same inflorescence are simultaneously pollinated by insects creeping over them in search of nectar, or collecting or devouring pollen. For in the first stage of anthesis the pollen-grains, in the second stage the stigmatic papillae, are so far above the general level that insects must rub against them. It is thus highly probable that crossing will be effected; but in many cases automatic self-pollination takes place in the absence of insect visitors, for the branches of the style bend back, applying to the stigmatic papillae pollen still clinging to the sweeping hairs.

Nectar is secreted by a ridge surrounding the base of the style. It is so abundant as to rise in the corolla-tube, and is protected from rain by the filaments which converge above it. It is accessible both to long-tongued and short-tongued insects. The Compositae are therefore typical examples of flower class **S.**

In the markedly protandrous hermaphrodite flowers pollen is discharged even in the bud into the anther-cylinder that surrounds the style with its apposed stigmas. As the style elongates it sweeps the pollen before it out of the cylinder, so that the grains accumulate above the opening of the flower. This is effected with the help of hairs or papillae which beset the surface of the style, and which have a characteristic form and arrangement in different genera. (*Cf.* Fig. 189.) Pollen adheres to the ventral surface of insect visitors, this being rendered the more certain because the filaments contract when touched by the proboscis as it is thrust towards the nectar, so that the anther-tube often sinks several millimetres, and the contained pollen is pressed out. After this has been accomplished the stylar branches diverge, and the stigmatic papillae, which usually stud their inner surfaces, become receptive.

Another advantageous peculiarity of the Compositae, remarked by Sprengel, is that the heads close in unfavourable weather.

A short account (taken from Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 318) has already been given of the geitonogamy common in Compositae (Vol. I, pp. 41–2). (Also *cf.* Fig. 191.)

A. **Tubuliflorae** Less.

Disk-florets not ligulate.

1. Sub-order Corymbiferae Juss.

Florets either all tubular or, more commonly, ray-florets ligulate. Style not thickened at the tip, and devoid of a terminal circlet of sweeping hairs.

(*a*) Tribe ***Eupatoroideae*** Less.

Style of the hermaphrodite florets cylindrical and two-branched. Stylar branches ½-terete or somewhat clavate, pubescent above.

412. Eupatorium L.

Flowers protandrous, but few in each of the heads, which are arranged in dense terminal corymbs. The stylar branches are as long as the corolla-tube, and beset for their lowest fourth with a row of stigmatic papillae on each side; above this densely clothed with sweeping-hairs. Flower class **SL.**

1310. **E. cannabinum** L. (Herm. Müller, 'Fertilisation,' pp. 318–20, 'Alpenblumen,' p. 450, 'Weit. Beob.,' III, p. 92; MacLeod, Bot. Jaarb. Dodonaea,

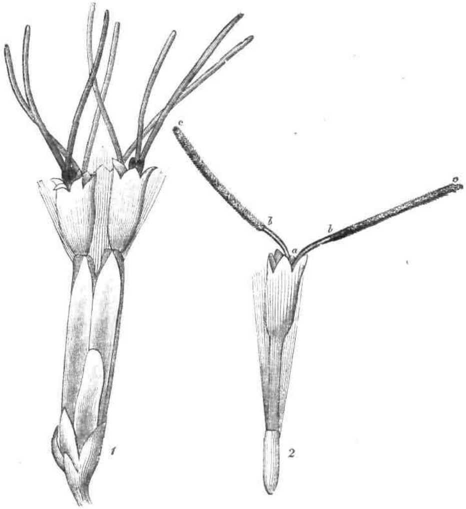


FIG. 190. *Eupatorium cannabinum, L.* (after Herm. Müller). (1) A head with four florets, in the first (male) stage. (2) A single floret in the second (female) stage. From *a* to *b* each branch of the style is beset with a line of stigmatic papillae on each side; from *b* to *c* it is covered with sweeping-hairs.

Ghent, iii, 1891, v, 1893, vi, 1894; Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen, pp. 16–17, Taf. I, Figs. 14–19; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Herbst-Beob.')—In this species, according to Hermann Müller, each head usually contains only five, or even only four, dull-red florets. As, however, there are generally several hundred such heads arranged in dense

corymbose inflorescences, these are very conspicuous, especially as the greatly protruding stylar branches are white, while the margins of the involucral bracts are reddish in colour. The corolla-tube is 2½ mm. long, ending in a bell scarcely 2 mm. in length, from which the stylar branches project for about 5 mm.

In the first stage of anthesis the lowest part of the stylar branches (beset with stigmatic papillae) remains in the corolla-tube, while their upper three-fourths (covered with sweeping-hairs) project freely, and diverge so widely that insect visitors touch them, and rub off the pollen-grains clinging to the sweeping-hairs. In the second stage of anthesis the lower parts of the stylar branches project from the bell, so that insects probing for nectar must come into contact with the stigmatic papillae. Warnstorf adds that the anther-cylinders do not project out of the florets, and that the sweeping-hairs are thick, bluntly conical papillae, sometimes two-celled, delicately striated, and projecting horizontally. The pollen-grains are white, roundish to ellipsoidal, spinose, on an average 25 μ in diameter.

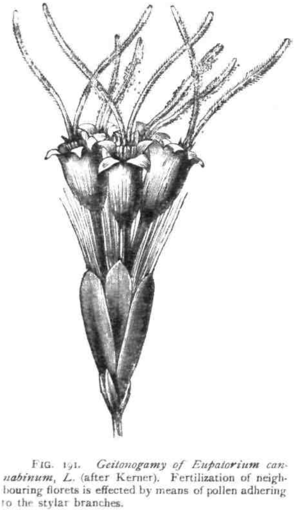


FIG. 191. *Geitonogamy of Eupatorium cannabinum, L.* (after Kerner). Fertilization of neighbouring florets is effected by means of pollen adhering to the stylar branches.

If insect visitors are sufficiently numerous to remove the pollen from the sweeping-hairs before the stigmas project, cross-pollination is assured. If, however, pollen still clings to the sweeping-hairs when the lower parts of the stylar branches protrude, self-pollination is equally possible as the result of insect-visits. Automatic self-pollination cannot take place in the total absence of visitors, but geitonogamy undoubtedly may, for the stylar branches spread out so far that they occasionally touch the stigmas of adjacent florets. Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 319) calls particular attention to this possibility (Fig. 191).

VISITORS.—Of these Lepidoptera are the chief observed.

Herm. Müller (Alps) noticed 6 Diptera, 4 Hymenoptera, and 6 Lepidoptera. He (H. M.) and Buddeberg (Budd.) give the following list for Central Germany.—

A. Diptera. (*a*) *Muscidae*: 1. Dexia canina *F.* (H. M.); 2. Echinomyia fera *L.* (H. M.); 3. Lucilia albiceps *Mg.* (H. M.). (*b*) *Syrphidae*: 4. Eristalis arbustorum *L.* freq., po-dvg. (H. M.); 5. E. nemorum *L.*, do. (H. M.); 6. E. tenax *L.*, do. (H. M.). **B. Hymenoptera.** *Apidae*: 7. Apis mellifica *L.* ☿, skg. (H. M.); 8. Psithyrus vestalis *Fourcr.* ♂, skg. (H. M.). **C. Lepidoptera.** (*a*) *Bombycidae*: 9. Callimorpha dominula *L.*, skg. (Budd.). (*b*) *Rhopalocera*: all skg.: 10. Argynnis paphia *L.*, freq. (H. M., Budd.); 11. Erebia medusa *S.V.* (H. M.); 12. Hesperia

lineola *O.* (H. M.); 13. Lycaena sp. (H. M.); 14. Melanargia galatea *L.* (H. M.); 15. Pararge egeria *L.* (H. M.); 16. Pieris rapae *L.* (H. M.); 17. Thecla quercus *L.* (H. M.); 18. Vanessa io *L.*, freq. (H. M., Budd.). **D. Neuroptera.** 19. Panorpa communis *L.*, skg. (H. M.).

Burkill observed the following on the east coast of Scotland ('Fls. and Insects in Great Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes picipes *Sturm*, po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia brevicornis *Zett.*, po-dvg.; 3. A. radicum *L.*, skg. and po-dvg.; 4. Calliphora erythrocephala *Mg.*, skg.; 5. Lucilia cornicina *F.*, do.; 6. Onesia sepulcralis *Mg.*; 7. Scatophaga stercoraria *L.*; 8. Siphona geniculata *Deg.* (*b*) *Syrphidae*: 9. Eristalis horticola *Deg.*, skg.; 10. E. pertinax *Scop.*, do.; 11. E. tenax *L.*, do.; 12. Platycheirus manicatus *Mg.*; 13. Sphaerophoria scripta *L.*; 14. Syritta pipiens *L.*; 15. Syrphus ribesii *L.* (*c*) *Phoridae*: 16. Phora sp. **C. Hymenoptera.** (*a*) *Apidae*: 17. Bombus lapidarius *L.*, skg. (*b*) *Formicidae*: 18. Myrmica rubra *L.*, creeping over the inflorescences. **D. Lepidoptera.** *Rhopalocera*: 19. Vanessa urticae *L.*, skg.

The following were recorded by the observers, and for the localities stated.—

Knuth (Glücksburg), 2 butterflies, skg. (Vanessa io *L.*, and Pieris napi *L.*), and a hover-fly (Eristalis tenax *L.*). The same at Kiel, also Apis. von Dalla Torre (Tyrol), a true wasp (Vespa norvegica *F.*), a bee (Halictus leucopus *K.* ♀), a parasitic humble-bee (Psithyrus campestris *Pz.* ♂), and 2 humble-bees (Bombus muscorum *F.* ☿). F. F. Kohl (Tyrol), the ruby-wasp Cleptes semiauratus *L.* Schletterer (Tyrol), a bee (Halictus leucopus *K.*), a parasitic humble-bee (Psithyrus campestris *Pz.*), and 3 humble-bees (Bombus pomorum *Pz.*; B. soroënsis *L.*; B. variabilis *Schmiedekn.*). Gerstäcker (Kreuth), the commonest parasitic humble-bee Psithyrus vestalis *Fourcr.* Alfken (Juist), the parasitic humble-bee Psithyrus rupestris *F.* ♂. Schiner (Austria), the Tabanid Silvius vituli *F.* Frey (Switzerland), the Muscid Callimorpha hera *L.*, and the moth Tortrix inopiana *Haw.* MacLeod (Flanders), Apis and a Muscid (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 373); also 4 hover-flies, a Muscid, and 3 Lepidoptera (op. cit., v, 1893, p. 410); (Pyrenees), 3 Lepidoptera and a Muscid (op. cit., iii, 1891, p. 359).

1311. **E. riparium** Regel.—Hildebrand (op. cit.) states that the mechanism of this species agrees with that of E. cannabinum.

1312. **E. ageratoides** L.—

Visitors.—Loew observed the following visitors in the Berlin Botanic Garden.—

Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. E. nemorum *L.*; 5. Syritta pipiens *L.*; 6. Syrphus corollae *F.*

1313. **E. purpureum** L.—

Visitors.—Loew observed the following visitors in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. E. tenax *L.*; 3. Helophilus floreus *L.*; 4. Melithreptus scriptus *L.*; 5. Syritta pipiens *L.*; 6. Syrphus ribesii *L.*, lkg. and po-dvg. in the styles of some florets. **B. Hymenoptera.** *Apidae*: 7. Apis mellifica *L.* ☿, skg.; 8. Bombus terrester *L.* ♀ and ♂, do.; 9. Psithyrus rupestris *F.* ♂, do.; 10. P. vestalis *Fourcr.* ♂. **C. Lepidoptera.** *Rhopalocera*: 11. Pieris brassicae *L.*, skg.; 12. Vanessa c-album *L.*, do.

413. Vernonia Schreb.

1314. **V. fasciculata** Michx.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus balteatus *Deg.* **B. Hymenoptera.**

Apidae: 2. Apis mellifica *L.* ☿, skg.; 3. Bombus lapidarius *L.* ♂, do.; 4. B. terrester *L.* ♂, do.; 5. Psithyrus vestalis *Fourcr.* ♂, do. **C. Lepidoptera.** *Rhopalocera*: 6. Pieris brassicae *L.*, do.

1315. **V. praealta** Ell.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Hymenoptera. *Apidae*: 1. Apis mellifica *L.* ☿, skg.; 2. Bombus terrester *L.* ♂, do.; 3. Psithyrus vestalis *Fourcr.* ♂, do. **B. Lepidoptera.** *Rhopalocera*: 4. Pieris brassicae *L.*, skg.

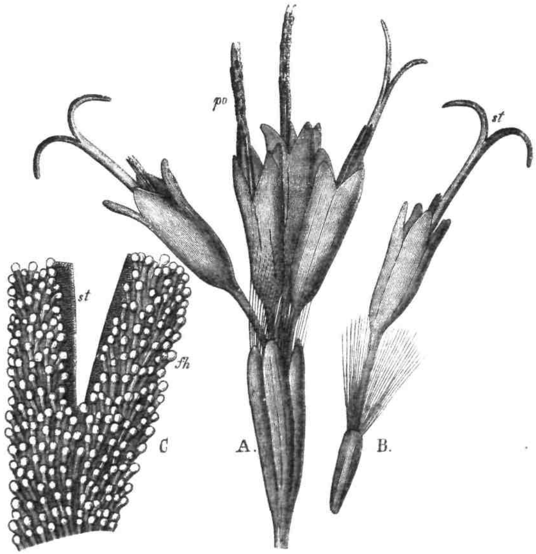


Fig. 192. *Adenostyles alpina, Bluff et Fing* (after Herm. Müller). *A.* A head with four florets; the two in the middle are in the first (male) stage, the two outer ones in the second (female) stage (× 7). *B.* Single floret (× 7). *C.* Part of a stylar branch (× 80). *fh*, sweeping-hairs; *po*, pollen clinging to these; *st*, stigmas.

414. Adenostyles Cass.

Flowers protandrous, but few in each of the heads, which are arranged in dense corymbs. The whole outer surface of the style is thickly covered with small capitate sweeping-hairs. These are short-stalked, and their heads are glandular. The inner surfaces of both stylar branches are closely beset with minute stigmatic papillae. Kerner states that some species possess no sweeping-hairs. Flower class **SL.**

1316. A. alpina Bluff et Fing (=A. viridis *Cass.*, and Cacalia alpina *L.*). (Herm. Müller, 'Alpenblumen,' pp. 450–2.)—As in Eupatorium cannabinum, each head in this species contains only 4–5 florets; the corolla consists of a tube about 3 mm. long, with a slightly longer bell. When the two stylar branches diverge they often rupture the anther-cylinder, and ultimately bend back so far that the stigmatic papillae touch the sweeping-hairs, so that if any pollen-grains still cling to these automatic self-pollination may be effected.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), chiefly Lepidoptera (21), less frequently beetles (14) and Hymenoptera (4). Schletterer and von Dalla Torre (Tyrol) record the humble-bee Bombus terrester.

1317. A. albida Cass. (=A. albifrons *Reichb.*). (Herm. Müller, 'Alpenblumen,' p. 452.)—Kerner states that there are no sweeping-hairs in this species, so that the pollen is pressed out by the ends of the stylar branches.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), only Diptera (Echinomyia and Eristalis), though probably the chief visitors are Lepidoptera as in the last species. Loew (Altvatergebirge), a Chrysomelid (Chrysomela cacaliae *Schr.*, subsp. senecionis *Schumm.*), and a Pyralid (undetermined sp., skg.).

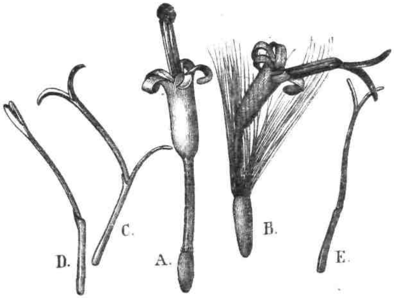


Fig. 193. *Homogyne alpina, Cass.* (after Herm. Müller). *A.* Disk-floret in the first (male) stage; pappus omitted. *B.* Ditto, in the second female) stage. *C. D. E.* Ray-florets with reduced corolla limb and long protruding style.

1318. A. hybrida DC. (=A. candidissima *Cass.*). (Herm. Müller, 'Alpenblumen,' p. 452.)—

Visitors.—Herm. Müller only observed the hover-fly Eristalis tenax *L.*, skg. and po-dvg.

415. Homogyne Cass.

Gynomonoecious, with protandrous hermaphrodite florets, many of which are aggregated into a head. Ray-florets female, filiform; disk-florets hermaphrodite, tubular. Stylar branches of the latter beset with sweeping-hairs externally, and stigmatic papillae internally. Flower class **SL.**

1319. H. alpina Cass. (=Tussilago alpina *L.*). (Herm. Müller, 'Alpenblumen,' pp. 452–4; Ricca, Atti Soc. ital. sc. nat., Milano, xiii, 1870; Kerner, 'Nat. Hist. Pl.,'

Eng. Ed. 1, II.)—In this species, the ray-florets are female, nectarless, with a more or less reduced corolla-limb. The disk-florets are hermaphrodite and distinctly protandrous, so that, according to Hermann Müller, automatic self-pollination is completely excluded or almost so. Kerner states that geitonogamy is possible, by curving outwards of the pollen-covered stylar branches.

VISITORS.—Ricca observed flies; Herm. Müller chiefly Lepidoptera (28), also 5 flies and a humble-bee.

416. Tussilago L.

Monoecious. Disk-florets male, with vestigial pistils; the ray-florets female; multiseriate, ligulate. The stylar branches of the female florets possess stigmatic papillae on their inner surfaces, and (useless) sweeping-hairs externally and apically. In male flowers these branches remain united almost to their tips; externally and above they are covered with short sweeping-hairs.

1320. T. Farfara L. (Sprengel, 'Entd. Geh.,' pp. 374–6; Herm. Müller, 'Fertilisation,' pp. 333–4, 'Alpenblumen,' pp. 454–5; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 85, 157; Kerner, 'Nat. Hist. Pl., 'Eng. Ed. 1, II.)—In this species 30–40 golden-yellow purely male disk-florets are surrounded by about 300 purely female ray-florets, similarly coloured, and multiseriate. The head expands in the sunshine into a surface 20–25 mm. broad, and closes at night or during dull weather. The male florets possess an ovary containing a vestigial ovule, and there is a yellow nectar-ring at the base of the style. The pollen is pushed out of the anther-cylinder by the sweeping-hairs.

The nectarless female ray-florets possess a corolla-tube 3 mm. long, with a narrow linear limb 6–8 mm. in length, and directed outwards. The style projects 2–3 mm. from the floret, and is divided at its end into two stylar branches about $\frac{1}{2}$ mm. long, and papillose internally. The stigmas of the ray-florets become receptive a considerable time before the pollen is swept out of the male ones. There is therefore constant crossing of different stocks when insect-visits are sufficiently numerous. Owing to the unisexual character of the florets, automatic self-pollination is necessarily excluded. Kerner states that automatic geitonogamy takes place when the ligulate ray-florets close about 5–6 p.m. In doing so, they bend over the disk-florets in such a way that they touch the pollen-masses which have been swept out of the anther-cylinders of the male florets. The pollen-grains adhere to the ligulate florets, and when the head opens again next morning some of them slide down to the respective stigmas. Warnstorf describes the pollen-grains as golden-yellow in colour, rounded to ellipsoidal, densely spinose, about 44 μ long and 37 μ broad.

According to Burkill ('Fertlsn. of Spring Fls.'), the heads that blossom on the cliffs of the Yorkshire coast contain about 200 to 300 female florets and about 40 male ones, and are 20–36 mm. in diameter; while those on the lower slopes of the shore only attain a diameter of about 15 mm. During anthesis the corolla-tubes of the disk-florets lengthen about 1 mm.; the ligulate florets simultaneously increase in size, and their receptacles broaden. The head, therefore, becomes somewhat more conspicuous as it passes from the first to the last stage. As

the heads become older, and the growth of the corollas ceases, the power of closing at night is gradually lost; this is well known to depend upon differential growth of the ligulate florets. Female florets are consequently better protected against unfavourable weather than male ones. After the female florets have been fertilized they still retain their fresh appearance, and it is only when the male florets, which open much later, have discharged their pollen, that the heads wither.

VISITORS.—Alfken and Höppner (H.) observed the following at Bremen.—

A. Diptera. (*a*) *Conopidae*: 1. Myopa sp. (*b*) *Muscidae*: 2. Anthomyia sp.; 3. Lucilia caesar *L.*, skg. and po-cltg.; 4. Musca domestica *L.*; 5. Pollenia vespillo *F.*, freq., skg. (*c*) *Syrphidae*: 6. Cheilosia sp.; 7. Eristalis tenax *L.*, very common, skg. **B. Hymenoptera.** (*a*) *Apidae*: 8. Andrena albicans *Müll.* ♂, not infrequent, skg.; 9. A. albicrus *K.* ♂, rare, skg.; 10. A. apicata *Sm.* ♂ and ♀ (H.); 11. A. clarkella *K.* ♀, not infrequent, skg.; 12. A. flavipes *Pz.* ♀, freq., skg. and po-dvg., ♂ freq., skg.; 13. A. gwynana *K.*, not infrequent, ♀, skg. and po-cltg., ♂ skg.; 14. A. lapponica *Zett.* ♂; 15. A. morawitzi *Ths.* ♀ and ♂, skg. (H.); 16. A. nigroaenea *K.* ♀ and ♂ (H.); 17. A. parvula *K.*, freq., ♀ skg. and po-cltg., ♂ skg.; 18. A. praecox *Scop.* ♀ and ♂; 19. A. rufitarsis *Zett.* ♀ and ♂; 20. A. thoracica *F.*, rare, ♀ skg. and po-cltg., ♂ skg.; 21. A. tibialis *K.* ♂ (H.); 22. A. tibialis *K.* ♀, rare; 23. A. varians *K.* ♀ and ♂, rare; 24. Apis mellifica *L.*, ☿, very common, skg. and po-dvg.; 25. Bombus agrorum *F.* ♀ (H.); 26. B. jonellus *K.* ♀, freq.; 27. B. terrester *L.* ♀, do.; 28. Nomada bifida *Ths.* ♂, one; 29. N. borealis *Zett.* ♀ and ♂, not infrequent, skg.; 30. N. fabriciana *L.* ♀, one, skg. ♂, freq., skg.; 31. N. flavoguttata *K.*, var. höppneri *Alfken* ♀ and ♂. (*b*) *Sphegidae*: 32. Ammophila sabulosa *L.* ♂, freq., skg.; 33. A. hirsuta *Scop.* ♀ and ♂, skg. **C. Lepidoptera.** (*a*) *Nymphalidae*: 34. Vanessa antiopa *L.*, skg. (H.); 35. V. io *L.*, freq., skg.; 36. V. urticae *L.*, do. (*b*) *Pieridae*: 37. Rhopalocera rhamni *L.*, freq., skg.

Burkill gives the following list for the Yorkshire coast ('Fertlsn. of Spring Fls.').—

A. Araneidae. 1. Xysticus pini *Hahn.*, freq., lying in wait for flies. **B. Coleoptera.** 2. Meligethes picipes *Sturm.*, po-dvg.; 3. Omalium florale *Payk.*; 4. Thyamis fuscicollis *Foudr.* **C. Diptera.** (*a*) *Muscidae*: 5. Calliphora (Onesia) cognata *Mg.*; 6. C. erythrocephala *Mg.*, skg.; 7. C. (Onesia) sepulcralis *Mg.*, do.; 8. C. vomitoria *L.*, do.; 9. Actora aestuum *Mg.*, po-dvg.; 10. Coelopa sp.; 11. Ephydra sp.; 12. Helomyza sp., skg. and po-dvg.; 13. Hylemyia sp.; 14. Lasiops sp., skg.; 15. Lucilia cornicina *F.*, skg. and po-dvg.; 16. Phorbia sp.; 17. Pollenia rudis *F.*; 18. Scatophaga stercoraria *L.*, skg. and po-dvg.; 19. Sepsis nigripes *Mg.*, do. (*b*) *Phoridae*: 20. Phora sp. (*c*) *Syrphidae*: 21. Eristalis horticola *Deg.*; 22. E. pertinax *Scop.*, skg. and po-dvg.; 23. Melanostoma quadrimaculata *Verral*, skg.; 24. Platycheirus sp.; 25. Syrphus lasiophthalmus *Zett.*; 26. S. macularis *Zett.* (*d*) *Cecidomyidae*: 27. Cecidomyia sp. **D. Hymenoptera.** (*a*) *Apidae*: 28. Andrena clarkella *K.* ♀ and ♂, skg.; 29. A. gwynana *K.* ♀ and ♂; 30. A. nigroaenea *K.* ♀ and ♂; 31. Apis mellifica *L.*, skg. and po-cltg.; 32. Bombus agrorum *F.*, skg.; 33. B. terrester *L.*, do. (*b*) *Formicidae*: 34. Formica fusca *L.* (*c*) *Ichneumonidae*: 35. Ichneumon sp. **E. Lepidoptera.** *Rhopalocera*: 36. Vanessa urticae *L.* skg. **F. Thysanoptera.** 37. Thrips sp.

The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel), the honey-bee, very freq., skg. and po-cltg. Herm. Müller (Westphalia), 4 bees—1. Apis mellifica *L.*, skg. and po-cltg.; 2. Andrena fulvicrus *K.* ♀, skg.; 3. A. gwynana *K.* ♀, skg. and po-dvg.; 4. A. parvula *K.* ♀, do.; flies (Bombylius major *L.*, skg., and Eristalis tenax *L.*, po-dvg.); and the beetle Meligethes, freq., po-dvg.; also (Alps), 21 flies, 3 bees, an ant, and 2 Lepidoptera. Wüstnei (Alsen), 2 bees (Andrena tibialis *K.*, and A. ruficrus *Nyl.*). MacLeod

(Flanders), Apis, a short-tongued bee, and 3 flies (*Bot. Jaarb. Dodonaea, Ghent*, vi, 1894, p. 373). Friese (Fiume), the bee Andrena taraxaci *Gir.* Schneider (Arctic Norway), 2 humble-bees—Bombus hypnorum *L.*, and B. terrester *L.* (Tromsø Mus. Aarsh., 1894).

417. Petasites L.

Dioecious-polygamous. Male florets with a bell-shaped regularly five-toothed limb to the corolla: female florets filiform, with the corolla-limb obliquely truncated. The stylar branches, especially in male florets, covered externally with sweeping-hairs; papillose on their inner surfaces in female florets. Kerner points out that sexually differing stocks also differ from one another in appearance. In one kind of plant there are numerous pseudo-hermaphrodite pollen-florets in the disk, and a small number of female flowers round the margin; in the other kind the relative numbers are reversed.

1321. **P. officinalis** Moench (=P. vulgaris *Desf.*, Tussilago Petasites *L.*, the so-called hermaphrodite plant, and T. hybrida *L.*, the female plant). (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 35–40, Taf. IV, Figs. 1–19; Kirchner, 'Flora v. Stuttgart,' p. 690; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Herm. Müller, 'Weit. Beob.,' III, p. 92; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 411; Knuth, 'Bloemenbiol. Bijdragen'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The florets of this species are of a dull-purple colour, rarely pale-red, or nearly white. The plant occurs in two forms quite different from one another in appearance. Kerner says that in one of these there are numerous pseudo-hermaphrodite pollen-florets in the disk, and a smaller number of purely female ray-florets; in the other form the relative numbers are reversed. Male stocks possess shorter peduncles and crowded inflorescences; the 22–38 florets in a head, according to Kirchner, are either all similar and nectariferous, or there may be as many as three hermaphrodite florets among them. The ovule is usually vestigial; the style presents a club-shaped somewhat compressed thickening under its branches, which are beset with sweeping-hairs. The stylar branches curve away a little from each other, and are covered externally with short sweeping-hairs; they are devoid of stigmatic papillae internally. The corolla of the male florets is tubular below, expanding above into a bell with five recurved lobes.

For the female plants, Kirchner describes the inflorescences as taller but less dense. Each head contains about 140 florets, of which 1–3 central ones are male. The female florets are nectarless and show no trace of stamens. Their corolla is in the form of a long narrow tube, which is produced into two lips, one narrow and the other broader. The style is filiform and smooth; its two branches are covered with short hairs externally, and beset with stigmatic papillae internally. The 1–3 male florets in the centre possess a bifurcated style, but slightly if at all thickened, and covered with sweeping-hairs. The annular nectary secretes abundantly; the anthers are vestigial and produce no pollen.

Burkill observed only male inflorescences on the Yorkshire coast ('Fertlsn. of Spring Fls.'). At Neu-Ruppin (Brandenburg) the species also only occurs, according to Warnstorf, in one form bearing pseudo-hermaphrodite infertile pollen-florets. The stylar branches, which are densely covered with papillose sweeping-

hairs, remain permanently apposed, and project far out of the florets, their only function being to brush the pollen-masses out of the anther-cylinder. Here, therefore, we have a third different kind of stock; the two others have already been described.

The pollen-grains are white, roundish to ellipsoidal, up to 37 μ long and 31 μ broad, with long spines adapted to secure adhesion to the stigmatic papillae.

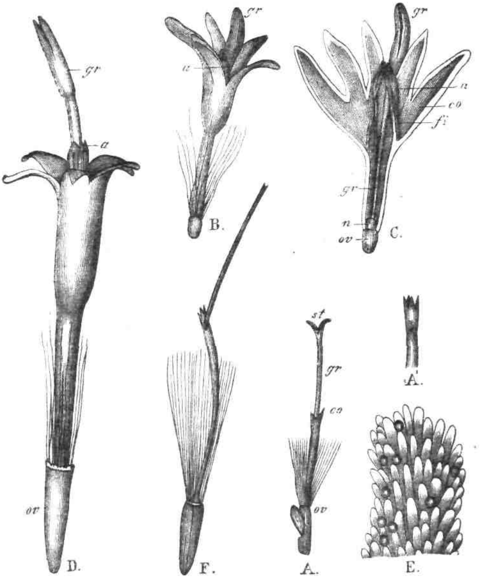


FIG. 194. *Petasites albus, Gaertn.* (after Herm. Müller). *A.* Sexual floret from a female head (*ov*, ruptured ovary with projecting ovule). *A'.* Upper part of a corolla. *B.* Nectar-secreting floret of the female head. *C.* Ditto, split longitudinally. *D.* Sexual nectar-secreting floret from a male head. *E.* Part of a stylar branch from the same floret. *F.* Degenerate floret from a male head.' (*A–D* and *F* × 7; *E* × 80.) *a*, anther-cylinder; *co*, corolla; *fi*, filament; *gr*, style; *n*, nectary; *ov*, ovary.

VISITORS.—The following were recorded by the observers and for the localities stated.—

Knuth (Kiel), the honey-bee. Warnstorf (Ruppin), do. Wüstnei (Alsen), the humble-bee Bombus terrester *L.* Alfken (Bremen), 2 humble-bees—1. Bombus lucorum *L.* ♀; 2. B. pratorum *L.* ♀. MacLeod (Belgium), 5 bees, 3 Lepidoptera, and small flies. Burkill (Yorkshire coast), a midge (Chironomus sp.), a bug (Heterocordylus sp.), and 2 bees (Andrena gwynana *K.* ♀, and Bombus terrester *L.*), skg.

1322. **P. albus** Gaertn. (=Tussilago alba *L.*, the hermaphrodite plant, and T. ramosa *Hoppe*, the female plant). (Herm. Müller, 'Fertilisation,' pp. 334–5, 'Alpenblumen,' pp. 455–9.)—This species is dioecious, with four different forms of floret. In the heads of the female stocks there are both nectar-secreting and nectarless sexual florets. In the heads of the male stocks there are often only nectar-secreting and pollen-producing florets, but about as frequent as these are heads which also include one or two florets producing neither nectar nor pollen.

VISITORS.—Herm. Müller (Alps) observed 6 flies, Lepidoptera (only 2 species, but very numerous individuals), 2 beetles.

1323. **P. fragrans** Presl.—

VISITORS.—Burkill observed the following **Diptera** on the Yorkshire coast ('Fertlsn. of Spring Fls.').—

(*a*) *Muscidae*: 1. Lucilia cornicina *F.*; 2. Onesia cognata *Mg.*, po-dvg.; 3. O. sepulcralis *Mg.*, do. (*b*) *Syrphidae*: 4. Eristalis pertinax *Scop.*; 5. Melanostoma quadrimaculata *Verral*.

1324. **P. frigida** Fries.—According to the observations of Lindman on the Dovrefjeld, this northern species is dioecious, though to a lesser degree than P. albus. The florets are odourless. In male heads the ray-florets are purely female: the reddish stylar branches project from the large but few male florets, and have not only the function of sweeping out pollen, but also serve to attract insects. The female heads are smaller than the male: their disk-florets possess vestigial stamens, but their ray-florets are purely female. Ekstam gives the diameter of heads examined by him in Nova Zemlia as about 10 mm. According to Andersson and Hesselman ('Bidrag til Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' pp. 11–12), separate sexual forms are found in Spitzbergen, as on the Dovrefjeld. The male heads are 12·5–16 mm. long; the ligulate corolla-lobe of the ray-florets is strongly developed, and projects beyond the style. The female heads are only 11–14 mm. long: the ray-florets possess a shorter recurved corolla-lobe. The florets are bright reddish, the male ones being somewhat more strongly coloured. The fragrance is tolerably well marked (*cf.* Ekstam, 'Blütenbiol. Beob. a. Spitzbergen,' p. 6). Ripe fruits are but rarely formed in Spitzbergen, though De Geer (according to Nathorst) observed some on August 30, 1882.

VISITORS.—Ekstam saw a medium-sized fly in Nova Zemlia, but no visitors in Spitzbergen.

(*b*) Tribe *Asteroideae* Less.

Stylar branches linear, pointed, almost flat externally, otherwise as in the last tribe.

418. Aster Tourn.

Ray-florets uniseriate, female, usually differently coloured from the yellow disk-florets. Stylar branches broadened, covered with sweeping-hairs above, and beset by stigmatic papillae laterally and internally: their tips almost always inclined together in hermaphrodite florets.

Kerner states that the stylar branches of the ray-florets come into contact with the pollen-masses thrust out from the disk-florets. He also says that automatic

self-pollination occurs in the latter, by crossing of the stylar branches, but I have never noticed this.

1325. **A. alpinus** L. (Herm. Müller, 'Alpenblumen,' pp. 447–8; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Loew, 'Blütenbiol. Floristik,' p. 397; Knuth, 'Bloemenbiol. Bijdragen.')—This species is gynomonoecious, with protandrous hermaphrodite florets. The 50–150 yellow disk-florets are surrounded by 24–40 violet ray-florets, making up a terminal head 32–45 mm. in diameter. The style with its two diverging branches projects 2–3 mm. out of the ray-florets. From the bells of the disk-florets pollen is first extruded, and then the stylar branches, which curve together above, make their appearance. Kerner states that the stigmas of the female florets became receptive several days before pollen is produced by the neighbouring hermaphrodite florets.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 2 beetles, 2 bees, 36 Lepidoptera, and 9 flies. Knuth (Andermatt, July, 1878), 3 hover-flies (Eristalis tenax *L.*, Helophilus trivittatus *F.*, Melanostoma mellina *L.*, skg. and po-dvg.), and numerous Lepidoptera. Loew (Switzerland), a hover-fly (Cheilosia caerulescens *Mg.*), and a butterfly (Lycaena sp.).

1326. **A. Tripolium** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 86–7, 157, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235; MacLeod, Bot. Centralbl., Cassel, xxix, 1887.)—The heads of this species are about 20 mm. in diameter, each containing 20–30 bright violet female ray-florets, with a corolla-lobe

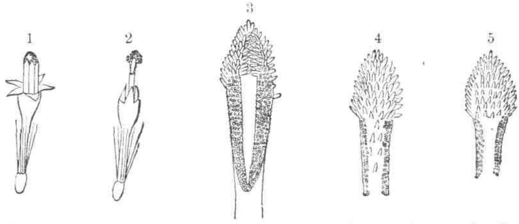


FIG. 195. *Aster Tripolium*, *L.* (from nature). (1) Floret in the first (male) stage: the pollen is being extruded from the tip of the anther-cylinder; the lobes of the corolla are spread out. (2) Ditto, in the second (female) stage; the projecting style is provided with apical sweeping-hairs, and below these are stigmatic papillae; the anther-cylinder has retracted into the corolla, the lobes of which now point upwards. (3) Greatly enlarged tip of the style of a floret in the female stage; above are the sweeping-hairs, and below the stigmatic papillae. (4) A stylar branch seen from the outside; above and in the middle are sweeping-hairs; below and laterally stigmatic papillae. (5) Ditto, from within.

about 11 mm. long and $2\frac{1}{2}$ mm. broad, and an equal number of yellow tubular hermaphrodite disk-florets. Owing to the colour contrast presented by the ray- and disk-florets, as well as the crowding together of numerous heads, the plant is rendered very conspicuous. The corolla of the disk-florets is contracted below like a stalk for a length of 4 mm., expanding above into a bell 2 mm. long. The pollen is swept out by the rhombic tips of the stylar branches, which are provided with sweeping-hairs directed obliquely upwards. When the anther-cylinder is empty, the stylar branches project 2 mm. from the inflorescence. Below the collecting-

hairs these branches are beset with stigmatic papillae internally, and on a longitudinal outer fold; they remain apposed at their tips. Insects visiting flowers in the first stage therefore get their under-surfaces covered with pollen, and will carry this to the stigmas of heads in the second stage. Automatic self-pollination is possible should insect-visits fail, for some pollen always remains between the stylar branches.

After fertilization the disk-florets assume a discoloured orange hue, and ultimately become brown. Now and then heads devoid of a ray occur. MacLeod says that these contain ten rather large disk-florets.

Visitors.—I observed the following at Kiel ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 157; 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 235).—

A. Diptera. (*a*) *Muscidae*: all skg.: 1. Anthomyia sp. ♀; 2. Aricia obscurata *Mg.*; 3. Dolichopus sp. ♀; 4. D. sp. ♂: 5. Lucilia caesar *L.*; 6. L. sp.; 7. Musca corvina *Fall.*; 8. Platycephala planifrons *F.*; 9. Pollenia rudis *F.*; 10. Scatophaga litorea *Fall.*; 11. S. merdaria *F.*; 12. S. stercoraria *L.*; 13. Siphona cristata *F.*; 14. Very small sp. (*b*) *Syrphidae*: 15. Melithreptus taeniatus *Mg.* ♀, skg.; 16. Syrphus corollae *F.* ♀, do. **B. Hymenoptera.** *Apidae*: 17. Apis mellifica, *L.* ☿, skg. and po-cltg.; 18. Bombus lapidarius *L.*, do.

Willis gives the following for the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part 1).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *F.*, freq., skg. and po-dvg. **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia radicum *L.*, freq., skg. and po-dvg.; 3. A. sp., skg.; 4. Hyetodesia incana *W.*, skg. and po-dvg.; 5. Lucilia cornicina *F.*, skg.; 6. Onesia sepulcralis *Mg.*, do.; 7. Scatophaga stercoraria *L.*, freq., skg.; 8. Tephritis vespertina *Loew*, skg. (*b*) *Syrphidae*: 9. Eristalis aeneus *Scop.*, freq., skg.; 10. E. horticola *Deg.*, skg.; 11. E. tenax *L.*, freq., skg.; 12. Platycheirus manicatus *Mg.*, skg. **C. Hymenoptera.** *Apidae*: all skg.: 13. Apis mellifica *L.*; 14. Bombus agrorum *L.*; 15. B. lapidarius *L.*; 16. B. pratorum *L.*; 17. B. terrester *L.* **D. Lepidoptera.** *Rhopalocera*: 18. Polyommatus phlaeas *L.*

The following were recorded by the authorities, and for the localities stated.—

Leege (Juist), the Noctuid Hydroecia nictitans *Bkh.* MacLeod (Belgium), Apis and some of the smaller bees. Scott-Elliot (Dumfriesshire), 5 humble-bees, 6 hover-flies, 12 Muscids, a Lepidopterid, and the beetle Meligethes (Scott-Elliot, 'Flora of Dumfriesshire,' p. 90).

1327. A. Amellus L. (Herm. Müller, 'Fertilisation,' p. 322; Kirchner, 'Beiträge,' pp. 63–4; Loew, 'Blütenbiol. Floristik,' p. 258.)—The vanilla-scented florets of this species are aggregated into heads of about 35 mm. diameter. Kirchner states that each of these contains twenty lilac-coloured female ray-florets, and twice as many golden-yellow hermaphrodite disk-florets. The former possess a corolla-tube 2 mm. long, with a tongue about 13 mm. in length; the two branches of the blue style are divergent. The corolla-tube of the disk-florets is 2½–3 mm. long, expanding into a bell 3 mm. in length. The style grows out of the anther-cylinder for about 3 mm. above the bell. Its branches are so curved that they turn their concave stigmatic surfaces towards each other, and meet at the tip; their outer sides subsequently become more strongly convex so that the branches curve past each other.

Visitors.—Herm. Müller noticed a hover-fly (Eristalis arbustorum *L.*, po-dvg.) in Thuringia.

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. E. nemorum *L.*; 5. Syrphus corollae *F.* **B. Hymenoptera.** (*a*) *Apidae*: 6. Halictus cylindricus *F.* ♀, skg. (*b*) *Sphegidae*: 7. Ammophila sabulosa *L.* (*c*) *Vespidae*: 8. Vespa germanica *F.* **C. Lepidoptera.** *Rhopalocera*: 9. Pieris brassicae *L.*, skg. Also on the var. *bessarabicus* Bernh. **A. Diptera.** (*a*) *Muscidae*: 1. Sepsis annulipes *Mg.*, resting on a ray-floret. (*b*) *Syrphidae*: 2. Eristalis nemorum *L.*; 3. Helophilus floreus *L.*; 4. Syritta pipiens *L.*; 5. Syrphus ribesii *L.* **B. Hymenoptera.** (*a*) *Apidae*: 6. Bombus terrester *L.* ♀, skg. (*b*) *Vespidae*: 7. Vespa germanica *F.* **C. Lepidoptera.** *Rhopalocera*: 8. Epinephele janira *L.*, skg.; 9. Vanessa urticae *L.*, do.

1328. A. Novae-Angliae L. (Knuth, 'Blütenbiol. Herbstbeob.')—In this species the branching stem attains a height of 1½ m., and bears numerous faintly fragrant heads 3½ cm. in diameter. About ⅓ this breadth is occupied by a hundred or so yellow disk-florets, and the rest by 80–90 blue ray-florets, which are usually in several series. The ray-florets are about 2 cm. long and 1½ mm. broad. In the evening and during wet weather these close in so as to cover the disk-florets. The flower mechanism is the same as in the other species of Aster: the tips of the stylar branches as they grow through the anther-cylinder brush out the pollen by means of small sweeping-hairs, and subsequently project so far that their stigmatic papillae are exposed.

This species is among the latest of the Asters to flower among those I have observed: even on October 16 (1891) there were numerous heads in the bud-condition, as well as others that had completely faded. On that day all the visitors mentioned below were found on the flowers, and the under-sides of all were covered with pollen.

Visitors.—Knuth records the following.—

A. Hymenoptera. *Apidae*: all skg.: 1. Apis mellifica *L.*, very common (a few seen as late as October 23); 2. Bombus lapidarius *L.*; 3. B. terrester *L.*; 4. B. sp. **B. Lepidoptera.** *Rhopalocera*: all skg.: 5. Vanessa io *L.*; 6. V. atalanta *L.*; 7. Argynnis sp. **C. Diptera.** (*a*) *Syrphidae*: all skg. and po-dvg.: 8. Eristalis tenax *L.*, very common (a few seen as late as October 23); 9. E. arbustorum *L.*; 10. Helophilus pendulus *L.*; 11. Syritta pipiens *L.* (*b*) *Muscidae*: 12. Onesia sepulcralis *Mg.*; 13. Sarcophaga sp.; 14. Lucilia cornicina *F.*, freq.; 15. Scatophaga stercoraria *L.*, freq. (a few seen as late as October 23); 16. S. merdaria *L.*; 17. Calliphora erythrocephala *Mg.*; 18. Pollenia rudis *F.*

1329. A. chinensis L. (=Callistephus chinensis *Nees*).—The flower mechanism of this species essentially agrees with that of previous ones.

Visitors.—The following were recorded by the observers and for the localities stated.—

Herm. Müller (Lippstadt), a bee (Coelioxys simplex *Nyl.* ♀, skg.), a butterfly (Vanessa urticae *L.*, skg.), and two hover-flies (Eristalis arbustorum *L.*, and E. nemorum *L.*, skg. and po-dvg.). Schletterer and von Dalla Torre (Tyrol), the bee Coelioxys elongata *Lep.* ♀. Macchiati made the following noteworthy observations in Sardinia, Calabria, and Piedmont (Nuovo Giorn. bot. Ital., xvi, 1884; Justs bot. Jahresber., xii, (1884) 1886, pp. 663–4).—Before the heads expand, an aphis (Aphis capsellae *Kaltenbach*) is often found living on the floral axes, where it is 'milked' by many ants. When the plant flowers in autumn, a new generation of aphides appears, i.e. the winged females, which fly to the open heads. The ants are unable to follow them there, for the sticky involucral bracts prove an insurmountable

barrier. This is of some significance in connexion with pollination, since the ants would frighten away pollinating insects, while the aphides with their sweet excretion help to attract them, and thus play the part of 'living nectaries.'

1330. **A. salicifolius** Scholl. (=A. salignus *Willd.*, and A. paniculatus *Lam.*). (Knuth, 'Blütenbiol. Herbstbeob.')—The tall much-branched stem bearing numerous heads serves to render the plants of this species conspicuous from a distance, attracting a larger number of species of insects than in almost any other autumnal form. Each head contains 20–30 ray-florets (15 mm. long) with blue corolla-lobes (10 mm. long and 2 mm. broad), and 30–40 yellow disk-florets 9 mm. in length, of which the ovary takes up 2 mm., the contracted part of the corolla-tube 4 mm., the nectar-containing bell 2 mm. (this is ½ mm. in diameter), and the corolla-lobes 1 mm. The flower mechanism agrees completely with those of Aster Tripolium *L.* and A. Amellus *L.*, except that the diameter of the bell is larger, and the nectar is therefore readily accessible even to insects with a stout proboscis or thick tongue. Ludwig states that the disk-florets of the older heads assume a bright red colour, as do those of A. parviflorus *Nees* (Justs bot. Jahresber., Leipzig, xiv, (1886) 1888, p. 806).

Visitors.—I observed the following.—

A. Diptera. (*a*) *Muscidae*: all skg.: 1. Anthomyia sp.; 2. Calliphora vomitoria *L.*; 3. Lucilia caesar *L.*; 4. L. cornicina *F.*; 5. Pollenia vespillo *F.*; 6. Sepsis cynipsea *L.* (*b*) *Syrphidae*: all skg. and po-dvg.: 7. Eristalis arbustorum *L.*; 8. E. nemorum *L.*; 9. Helophilus floreus *L.*; 10. H. pendulus *L.*; 11. Melanostoma gracilis *Mg.* **B. Hymenoptera.** 12. Bombus terrester *L.*, skg. **C. Lepidoptera.** 13. Vanessa io *L.*, skg.

Loew saw a hover-fly (Helophilus pendulus *L.* ♀ and ♂) in the Berlin Botanic Garden.

1331. **A. abbreviatus** Nees.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.*; 3. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 4. Eristalis nemorum *L.*; 5. Syritta pipiens *L.*; 6. Syrphus ribesii *L.* **B. Hymenoptera.** *Apidae*: 7. Apis mellifica *L.* ☿, skg. and po-dvg.

1332. **A. azureus** Lindl.—

Visitors.—Loew observed the following **Diptera** in the Berlin Botanic Garden.—

(*a*) *Muscidae*: 1. Lucilia caesar *L.* (*b*) *Syrphidae*: 2. Eristalis aeneus *Scop.*; 3. E. nemorum *L.*; 4. Syritta pipiens *L.*

1333. **A. brumalis** Nees.—

Visitors.—Loew observed a bee (Halictus leucozonius *Schr.* ♂, skg.) in the Berlin Botanic Garden.

1334. **A. concinnus** Willd.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.* (*b*) *Syrphidae*: 3. Eristalis aeneus *Scop.*; 4. E. tenax *L.*; 5. Melanostoma mellina *L.*; 6. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 7. Apis mellifica *L.* ☿, skg. and po-cltg. (*b*) *Sphegidae*: 8. Ammophila sabulosa *L.*

1335. **A. floribundus** Willd.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp. (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*; 3. E. nemorum *L.*; 4. E. tenax *L.*; 5. Syritta pipiens *L.*; 6. Syrphus luniger *Mg*. **B. Lepidoptera.** *Rhopalocera*: 7. Pieris brassicae *L.*, skg.

1336. **A. laevis** L.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Echinomyia fera *L.*; 2. Lucilia caesar *L.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. E. nemorum *L.*; 5. Helophilus floreus *L.* **B. Hymenoptera.** *Sphegidae*: 6. Oxybelus uniglumis *L.*

1337. **A. lanceolatus** Willd.—

Visitors.—Loew observed 4 Syrphids (1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. tenax *L.*; 4. Syrphus ribesii *L.*) and a bee (Prosopis communis *Nyl.* ♀, skg.) in the Berlin Botanic Garden.

1338. **A. Lindleyanus** Torr. et Gray.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Echinomyia fera *L.*; 2. Pyrellia cadaverina *L.*; 3. Sarcophaga carnaria *L.* (*b*) *Stratiomyidae*: 4. Chrysomyia formosa *Scop.* (*c*) *Syrphidae*: 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. E. tenax *L.*; 8. Helophilus floreus *L.*; 9. H. pendulus *L.*; 10. H. trivittatus *F.*; 11. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 12. Halictus rubicundus *Chr.* ♂, skg. (*b*) *Vespidae*: 13. Vespa crabro *L.* ☿. **C. Lepidoptera.** *Rhopalocera*: 14. Pieris brassicae *L.*, skg.

1339. **A. Novi Belgii** L.—

Visitors.—Loew observed a Muscid (Anthomyia sp.) and a Syrphid (Syritta pipiens *L.*) in the Berlin Botanic Garden.

1340. **A. paniculatus** Ait.—

Visitors.—Loew observed 2 Muscids (Anthomyia sp. and Echinomyia fera *L.*) and a Syrphid (Syritta pipiens *L.*) in the Berlin Botanic Garden.

1341. **A. paniculatus** Ait., var. **pubescens.**—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Pyrellia cadaverina *L.*; 2. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*; 4. Syrphus ribesii *L.* **B. Hymenoptera.** (*a*) *Apidae*: 5. Apis mellifica *L.* ☿, skg. and po-cltg.; 6. Bombus terrester *L.* ♂, skg. (*b*) *Sphegidae*: 7. Ammophila subulosa *L.* (*c*) *Vespidae*: 8. Vespa crabro *L.* ☿.

1342. **A. phlogifolius** Muhl.—

Visitors.—Loew observed 2 Syrphids (Eristalis nemorum *L.*, and Syritta pipiens *L.*) in the Berlin Botanic Garden.

1343. **A. prenanthoides** Muhl.—

Visitors.—Loew observed a Syrphid (Melithreptus menthastri *L.*), a bee (Halictus cylindricus *F.* ♂, skg.), and a wasp (Vespa germanica *F.*), in the Berlin Botanic Garden.

1344. **A. sagittifolius** Wedem.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Calliphora vomitoria *L.*; 3. Lucilia caesar *L.*; 4. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 5. Eristalis aeneus

Scop.; 6. E. nemorum *L.*; 7. E. tenax *L.*; 8. Helophilus floreus *L.*; 9. Melithreptus scriptus *L.*; 10. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 11. Apis mellifica *L.* ☿; 12. Bombus terrester *L.* ☿, skg.; 13. Sphecodes gibbus *L.* ♀, do. (*b*) *Sphegidae*: 14. Ammophila sabulosa *L.*

1345. **A. sparsiflorus** Michx.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.*; 3. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 4. Eristalis aeneus *Scop.*; 5. E. nemorum *L.*; 6. Helophilus floreus *L.*; 7. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 8. Apis mellifica *L.* ☿, skg. and po-cltg.; 9. Bombus terrester *L.* ☿, skg.; 10. Halictus sexnotatus *K.* ♀, do.

1346. **A. squarrosulus** Nees.—

Visitors.—Loew observed a Muscid (Echinomyia fera *L.*), 2 Syrphids (Eristalis arbustorum *L.*, and Helophilus floreus *L.*), and a wasp (Odynerus parietum *L.* ♀ and ♂), in the Berlin Botanic Garden.

419. Biotia DC.

1347. **B. commixta** DC.—

Visitors.—Loew observed the following **Diptera** *in the Berlin Botanic Garden.—*

(*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.*; 3. Lucilia caesar *L.*; 4. Pyrellia cadaverina *L.* (*b*) *Syrphidae*: 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. Helophilus floreus *L.*; 8. Syritta pipiens *L.*; 9. Syrphus ribesii *L.*

1348. **B. corymbosa** DC.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Echinomyia fera *L.*; 2. Pyrellia cadaverina *L.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. E. nemorum *L.* **B. Hymenoptera.** (*a*) *Apidae*: 5. Halictus cylindricus *F.* ♂, skg. (*b*) *Sphegidae*: 6. Ammophila sabulosa *L.* (*c*) *Vespidae*: 7. Vespa crabro *L.* ☿.

1349. **B. macrophylla** DC.—

Visitors.—Loew observed a Muscid (Echinomyia fera *L.*), and a butterfly (Polyommatus phlaeas *L.*, skg.), in the Berlin Botanic Garden.

1350. **B. Schreberi** DC.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Echinomyia fera *L.* (*b*) *Syrphidae*: 2. Eristalis nemorum *L.*; 3. E. tenax *L.* **B. Lepidoptera.** *Rhopalocera*: 4. Pieris brassicae *L.*, skg.; 5. Vanessa urticae *L.*, do.

420. Galatella Cass.

1351. **G. dracunculoides** Nees.—

Visitors.—Loew observed 3 Syrphids (1. Eristalis aeneus *Scop.*; 2. E. nemorum *L.*; 3. Helophilus trivittatus *F.*) in the Berlin Botanic Garden.

1352. **G. hyssopifolia** Nees.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Muscidae*: 1. Lucilia caesar *L.* **B. Hymenoptera.** (*a*) *Apidae*: 2. Apis mellifica *L.* ☿, skg.; 3. Prosopis communis *Nyl.* ♀, skg. (*b*) *Sphegidae*:

4. Ammophila sabulosa *L.*; 5. Oxybelus quattuordecimnotatus *Jur.* ♂; 6. O. uniglumis *L.* ♂.

1353. G. punctata Nees.—

VISITORS.—Loew observed 2 bugs (Aphanus lynceus *F.*, and Eurydema oleraceum *L.*), and a butterfly (Pieris brassicae *L.*, skg.), in the Berlin Botanic Garden.

421. Chrysocoma L.

Ray-florets neuter or absent: flower mechanism otherwise like that of Aster.

1354. C. Linosyris L. (=Aster Linosyris *Bernh.*, Linosyris vulgaris *Cass.*, and Galatella Linosyris *Reichb. f.*).—According to Hermann Müller ('Fertilisation,' pp. 322–4) the golden-yellow heads of this species are arranged in flat-topped inflorescences. Müller says that all the florets are alike. The protandrous florets which are in the first (male) stage expand their corolla-lobes, and are therefore more conspicuous than those in the second (female) stage, when these lobes are erect. The stylar branches ($1\frac{1}{2}$ mm. long) are beset to about their centre with a marginal row of stigmatic papillae on either side, above which they are expanded and covered externally and laterally by sweeping-hairs. Their tips do not diverge, but remain permanently apposed; otherwise they are separate as in Aster. It follows that insects get covered with pollen on their under-sides, when visiting florets in the first stage, and convey this to the stigmas of florets in the second stage. As all the florets of a head are in the same stage, it follows that many of them may be pollinated during a single visit.

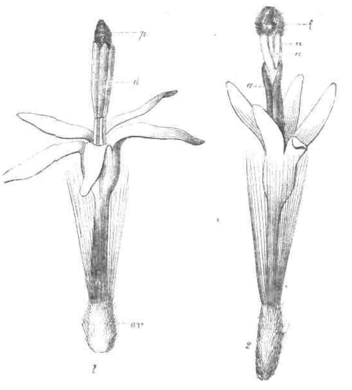


FIG. 196. *Chrysocoma Linosyris, L.* (after Herm. Müller). (1) Floret in the first (male) stage. (2) Ditto, in the second (female) stage. *a*, anthers, *f*, sweeping-hairs; *n*, stigmatic papillae; *ov*, ovary; *p*, pollen.

VISITORS.—Herm. Müller observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Ocyptera cylindrica *F.*, skg. (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*, very common, skg. and po-dvg.; 3. E. nemorum *L.*, do.; 4. Syritta pipiens *L.*, do. **B. Hymenoptera.** *Apidae*: 5. Halictus albipes *F.* ♀, very numerous, skg.; 6. H. cylindricus *F.* ♂, freq., skg.; 7. H. flavipes *F.* ♂, skg.; 8. H. nitidiusculus *K.* ♂, in large numbers, skg. **C. Lepidoptera.** (*a*) *Noctuidae*: 9. Plusia gamma *L.*, skg. (*b*) *Rhopalocera*: 10. Lycaena alsus *W.V.*, skg.; 11. Polyommatus dorilis *Hfn.*, do.

Loew records the following for the Berlin Botanic Garden.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella impustulata *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia sp.; 3. Chloria demandata *F.*; 4. Echinomyia fera *L.*;

5. Onesia sepulcralis *Mg.*; 6. Pyrellia cadaverina *L.* (*b*) *Syrphidae*: 7. Eristalis nemorum *L.*; 8. E. sepulcralis *L.*; 9. E. tenax *L.*; 10. Melanostoma mellina *L.*; 11. Melithreptus scriptus *L.*; 12. Syrphus balteatus *Deg.*; 13. S. pyrastri *L.*; 14. S. ribesii *L.*

422. **Bellidiastrum** Cass.

Ray-florets white, female; disk-florets yellow, hermaphrodite. The stylar branches of the disk-florets usually apposed above, covered with sweeping-hairs above, both externally and internally, and beset with stigmatic papillae on their outer margins below. Stylar branches of the female ray-florets devoid of sweeping-hairs, divergent, beset with marginal and apical stigmatic papillae.

1355. **B. michelii** Cass. (=Doronicum Bellidiastrum *L.*, Arnica Bellidiastra *All.*, and Aster Bellidiastrus *Scop.*). (Herm. Müller, 'Alpenblumen,' pp. 449–50.)—This species is gynomonoecious, with protandrous hermaphrodite florets. A head usually contains considerably more than 100 yellow disk-florets and 40–50 white ray-florets, making up a surface 30 or more mm. in breadth. The development of the florets progresses slowly in centrifugal order, so that there is never more than a narrow ring of disk-florets in bloom. Kerner states that the stigmas of the female florets become receptive several days before the pollen is ripe in the neighbouring hermaphrodite ones (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 312).

VISITORS.—Herm. Müller observed 5 beetles, 20 flies, 2 bees, and 14 Lepidoptera.

423. **Bellis** L.

Ray-florets white, uniserial, female; disk-florets yellow, bell-shaped, hermaphrodite. Stylar branches of the latter short, broadly ovoid, covered externally as far as their broadest part with sweeping-hairs, beneath which on the outer margin on either side is a short line of stigmatic papillae. Stylar branches of the female ray-florets elongated and devoid of sweeping-hairs: stigmatic papillae more numerous than in the hermaphrodite florets.

1356. **B. perennis** L. (Sprengel, 'Entd. Geh.,' p. 377; Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 23–4, Taf. II, Figs. 11–15; Herm. Müller, 'Fertilisation,' pp. 321–2, 'Weit. Beob.,' III, p. 92; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 87, 157; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II.)—This species is gynomonoecious. Hermann Müller states that the golden-yellow hermaphrodite disk-florets are only 1–2 mm. long; the white female ray-florets, often tinged with red, possess tongues about 5 mm. in length. The diameter of the heads averages about 16 mm., but some are considerably larger or smaller. On the North Frisian Islands I observed a breadth of 10 mm. and even less. The sweeping-hairs on the elongating styles of the disk-florets partly drive the pollen before them, partly hold it fast, and thus present it to insect visitors. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) says that the stigmas of the female ray-florets become receptive before the pollen of the disk-florets is ripe. The latter develop centripetally. The pollen-grains are pale yellow in colour, rounded, spinose, 21–5 μ in diameter. After fertilization has been effected, the stylar branches retract into the bell. During dull weather and at night the heads close.

VISITORS.—Herm. Müller saw 4 Muscids, 2 hover-flies, and 2 Lepidoptera in the Alps. He gives the following for Westphalia.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *L.*, po-dvg. (*b*) *Nitidulidae*: 2. Meligethes, po-dvg. (*c*) *Oedemeridae*: 3. Oedemera virescens *L.* (*d*) *Phalacridae*: 4. Olibrus sp. **B. Diptera.** (*a*) *Empidae*: 5. Empis livida *L.*, very common, skg.; 6. E. opaca *F.*, skg. (*b*) *Muscidae*: 7. Lucilia cornicina *F.*, numerous, po-dvg.; 8. Musca corvina *F.*, do.; 9. Scatophaga merdaria *F.*, do.; 10. S. stercoraria *L.*, do.; 11. Zophomyia tremula *Scop.*, po-dvg. (*c*) *Syrphidae*: 12. Ascia podagrica *F.*, po-dvg.; 13. Eristalis arbustorum *L.*, very common, po-dvg.; 14. E. pertinax *Scop.*, do.; 15. E. sepulcralis *L.*, do.; 16. E. tenax *L.*, do.; 17. Melithreptus scriptus *L.*, po-dvg.; 18. Rhingia rostrata *L.*, very common, po-dvg.; 19. Syritta pipiens *L.*, do., and skg. **C. Hymenoptera.** (*a*) *Apidae*: 20. Andrena nitida *Fourcr.* ♀, casually skg.; 21. A. parvula *K.* ♀, po-cltg.; 22. Apis mellifica *L.* ☿, in large numbers, po-cltg.; 23. Halictus albipes *F.* ♀, skg.; 24. H. cylindricus *F.* ♀, do.; 25. H. minutissimus *K.* ♀, in large numbers, po-cltg.; 26. Nomada flavoguttata *K.* ♂, skg.; 27. N. lineola *Pz.* ♂, do.; 28. Osmia rufa *L.* ♀, skg. and po-cltg.; 29. Sphecodes gibbus *L.* ♀, skg. (*b*) *Formicidae*: 30. Myrmica levinodis *Nyl.*, trying to suck. **D. Lepidoptera.** (*a*) *Rhopalocera*: 31. Coenonympha pamphilus *L.*, skg.; 32. Polyommatus dorilis *Hfn.*, casually skg. (*b*) *Tineidae*: 33. Adela violella *Tr.* ♂, skg.

Burkill observed the following on the Yorkshire coast ('Fertlsn. of Spring Fls.').—

A. Araneidae. 1. Xysticus pini *Hahn*, lying in wait for prey. **B. Coleoptera.** (*a*) *Curculionidae*: 2. Apion striatum *K.* (*b*) *Nitidulidae*: 3. Meligethes sp. **C. Diptera.** (*a*) *Bibionidae*: 4. Dilophus albipennis *Mg.* (*b*) *Muscidae*: 5. An Ephydrid; 6. Helomyza sp.; 7. Lucilia cornicina *F.*, skg. and po-dvg.; 8. Onesia cognata *Mg.*, do.; 9. Pollenia rudis; 10. Scatophaga stercoraria *L.*, skg. and po-dvg.; 11. Sepsis nigripes *Mg.*, po-dvg. (*c*) *Syrphidae*: 12. Eristalis pertinax *Scop.*, po-dvg.; 13. Melanostoma quadrimaculatum *Verral*; 14. Syrphus lasiophthalmus *Zett.* **D. Hymenoptera.** (*a*) *Apidae*: 15. Andrena clarkella *K.* ♂, skg.; 16. A. gwynana *K.* ♀; 17. Bombus terrester *L.* (*b*) *Ichneumonidae*: 18. Ichneumon sp. **E. Lepidoptera.** *Rhopalocera*: 19. Pieris rapae *L.*, skg.; 20. Vanessa urticae *L.*, do.

The following were recorded by the authorities, and for the localities stated.—

Knuth (North Frisian Islands), Apis, 4 hover-flies, 4 Muscids, a butterfly, and the beetle Meligethes ('Blütenbiol. Beob. a. d. nordfr. Ins.,' p. 157); (Helgoland), **Diptera.** All skg.: (*a*) *Muscidae*: 1. Coelopa frigida *Fall.*; 2. Homalomyia scalaris *F.* ♂; 3. Lucilia caesar *L.*; 4. Minute species. (*b*) *Syrphidae*: 5. Eristalis tenax *L.* (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 38); (Thuringia), a hover-fly (Melithreptus sp., skg.), and 2 Muscids, skg. (Anthomyia sp., and a small sp.). Alfken (Bremen).— **A. Diptera.** *Muscidae*: 1. Lucilia caesar *L.*, very common; 2. Musca domestica *L.*, one; 3. Pollenia rudis *F.*; 4. P. vespillo *F.*, rare. **B. Hymenoptera.** *Apidae*: 5. Andrena parvula *K.* ♀ and ♂, freq., skg.; 6. Halictus morio *F.* ♀, skg. and po-cltg.; 7. H. nitidiusculus *K.* ♀, freq., skg.; 8. Nomada flavoguttata *K.*, var. höppneri *Alfken* ♀ and ♂, do.; 9. Sphecodes ephippius *L.*; 10. S. sp. Loew (Silesia), a hover-fly (Syritta pipiens *L.*, skg.), and a bee (Trypetes truncorum *L.* ♀, po-cltg.) ('Beiträge,' pp. 30–1). Verhoeff (Norderney).—**A. Diptera.** (*a*) *Empidae*: 1. Hilara quadrivittata *Mg.* (*b*) *Muscidae*: 2. Anthomyia sp.; 3. Onesia floralis *R.-L.* **B. Lepidoptera.** *Pieridae*: 4. Pieris brassicae *L.*, skg. Krieger (Leipzig), the bee Halictus nitidiusculus *K.* Schletterer (Pola), the following Apidae: 5 bees— 1. Andrena carbonaria *L.*; 2. A. parvula *K.*; 3. A. thoracica *F.*; 4. Halictus calceatus *Scop.*; 5. H. malachurus *K.* Schmiedeknecht (Florence), on the authority of Piccioli, gives the bee Andrena florentina *Mgr.* MacLeod (Pyrenees), a bee, a Lepidopterid, 3 hover-flies, and 6 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 360); (Flanders), Apis, 9 species of Andrena, 6 species of Halictus, 4 other short-tongued

bees, 5 hover-flies, 10 Muscids, 5 Lepidoptera, 3 beetles (op. cit., v, 1893, pp. 412–14). H. de Vries (Netherlands), the bee Halictus leucozonius *Schr.* (Ned. Kruidk. Arch., Nijmegen, 2 ser., 2 deel, 1875). Scott-Elliot (Dumfriesshire), a hover-fly, and 2 Muscids ('Flora of Dumfriesshire,' p. 91).

424. **Stenactis** Cass.

Ray-florets slender, whitish, female, biseriate. Disk-florets bell-shaped yellow, hermaphrodite. Stylar branches as in Aster.

1357. **S. annua** Nees (=S. bellidiflora *A. Br.*, Aster annuus *L.*, and Erigeron annuus *Pers.*). (Kirchner, 'Beiträge,' pp. 64–5.)—Kirchner says that in this species there are about 100 ray-florets and numerous disk-florets, together forming a head 15–20 mm. in diameter. The tongues of the ray-florets are 5–6 mm. long; at the beginning of anthesis they are somewhat recurved, subsequently they spread out horizontally, and finally, when flowering is over, become erect—as they also do in the evening. The diameter of the disk-florets is 5–6 mm., their corolla is $2\frac{1}{2}$ mm. long, and the style projects beyond it another $\frac{1}{2}$ mm. The stylar branches are concave towards each other until anthesis is over.

425. **Diplopappus** Cass.

1358. **D. amygdalinus** Hook.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella impustulata *L.* (*b*) *Curculionidae*: 2. Apion miniatum *Germ.* **B. Diptera.** (*a*) *Muscidae*: 3. Anthomyia sp.; 4. Chloria demandata *F.*; 5. Echinomyia fera *L.*; 6. Graphomyia maculata *Scop.*; 7. Pyrellia cadaverina *L.* (*b*) *Syrphidae*: 8. Eristalis nemorum *L.*; 9. E. tenax *L.*; 10. Helophilus floreus *L.*; 11. Syritta pipiens *L.*; 12. Syrphus balteatus *Deg.*; 13. S. corollae *F.*; 14. S. ribesii *L.* **C. Hymenoptera.** (*a*) *Apidae*: 15. Apis mellifica *L.* ☿, skg. and po-cltg.; 16. Bombus terrester *L.* ♀, skg.; 17. Halictus cylindricus *F.* ♂, skg.; 18. Prosopis communis *Nyl.* ♀ and ♂, very numerous, skg.; 19. P. confusa *Nyl.* ♀, skg.; 20. Sphecodes ephippius *L.* ♂, skg. (*b*) *Ichneumonidae*: 21. Foenus sp. (*c*) *Sphegidae*: 22. Cerceris arenaria *L.* ♀; 23. Crabro vexillatus *Pz.* ♀; 24. Oxybelus bipunctatus *Oliv.* ♀ and ♂; 25. O. quattuordecimnotatus *Jur.* ♂; 26. O. uniglumis *L.* ♀ and ♂. (*d*) *Vespidae*: 27. Eumenes coarctatus *L.*; 28. Odynerus parietum *L.* ♀ and ♂; 29. O. parietum *L.*, var. renimacula *Lep.* ♀; 30. O. trifasciatus *F.* ♀; 31. Vespa crabro *L.* ☿. **D. Lepidoptera.** *Rhopalocera*: 32. Vanessa urticae *L.*, skg.

F. F. Kohl saw 2 true wasps (Eumenes pomiformis *F.*, and E. coarctatus *L.*) in the Tyrol.

426. **Erigeron** L.

Ray-florets multiseriate, female; either all ligulate or the inner ones tubular. Disk-florets hermaphrodite, tubular. The outer side of the stylar branches are beset with sweeping-hairs in the hermaphrodite florets, but devoid of them in female ones. These branches only diverge towards the end of anthesis, but are not recurved. Kerner says that automatic self-pollination is possible during later stages by contraction of the stylar branches, which are thus brought into contact with the pollen of the same flower.

1359. E. canadensis L. (Kirchner, 'Beiträge,' p. 65.)—In this species the heads are only 5 mm. long, 3 mm. thick, and 3 mm. broad above. The female ray-florets are very numerous. Kirchner gives their length as 3 mm., the slender filiform whitish tongue, which stands erect, measuring less than 1 mm. The disk-florets (3 mm. long) are all hermaphrodite, slender, tubular, and coloured yellow above. Automatic self-pollination does not appear to take place, despite the inconspicuousness of the heads (but *cf.* Kerner's statement, quoted above).

VISITORS.—Schenck noticed the bee Halictus pauxillus *Schenck* in Nassau.

1360. E. alpinus L. (Herm. Müller, 'Alpenblumen,' pp. 445–7.)—This species is gynomonoecious, with two forms of female florets. The yellow disk is 5–7 mm. in diameter, and surrounded by a ray of slender reddish-lilac florets, with tongues 5 mm. long. In these heads there are three kinds of florets:—(1) fertile female ray-florets, with tongues which enhance conspicuousness; (2) fertile female florets, devoid of tongues, between the margin and centre of the disk, serving only for the production of fruits; (3) hermaphrodite florets in the middle of the head, producing nectar and pollen, and with stigmas adapted for crossing, and probably, in the absence of insect visitors, for automatic self-pollination. Kerner says that the stigmas of the female florets become receptive a few days before pollen is produced in the hermaphrodite ones of the same inflorescence.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller, a fly and 2 Lepidoptera. MacLeod (Pyrenees), a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 359). Lindman (Dovrefjeld), a Lepidopterid.

1361. E. compositus Pursh. (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 65–7.)—This species is native to Greenland, arctic America, and the highest parts of the Rocky Mountains. Abromeit says that there are three varieties, in which the rose-coloured to pale-violet ray-florets are, respectively, 12 mm. long (var. *grandiflorus* Hook.), 6–7 mm. long (var. *breviradiatus*), and absent (var. *discoideus* A. Gr.).

1362. E. acris L. (Kirchner, 'Beiträge,' p. 65.)—In this species the heads are 8–10 mm. in diameter. Kirchner states that the female florets agree with Hermann Müller's description of E. alpinus. The 30–40 female ray-florets possess a tube 3–4 mm. long, and a slender lilac-coloured tongue of the same length. The outer part of the disk is occupied by a great number of other female florets, white in colour, and devoid of tongues. In the middle of the head there are 6–12 or more yellow hermaphrodite florets, of which the stylar branches ultimately diverge. When flowering is over the hermaphrodite florets assume a dirty dark-red colour.

1363. E. uniflorus L. (Herm. Müller, 'Alpenblumen,' p. 447.)—This species is gynomonoecious, with only one kind of female floret. The yellow disk is not more than 3–4 mm. in diameter; but the white or bright-red tongues of the numerous ray-florets extend this to a surface 8–15 mm. across.

The species is widely distributed in the arctic and boreal regions. Abromeit states that there are several sub-species in Greenland (e.g. E. pulchellus *Fries*, and E. eriocephalus *J. Vahl*), these being distinguished by the purple-red colour of the

involucre, the character of the investment of hairs, and so forth ('Bot. Ergeb. von Drygalski's *Grönlandsexped.*,' pp. 67–8). Andersson and Hesselman say that in Spitzbergen the flowering season lasts from the beginning of July till the first half of September, normal pollen being produced ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 10). Ekstam gives the diameter of the heads as 10–13 mm., and describes the florets as odourless, those of the ray being white or violet in colour ('Blütenbiol. Beob. a. Spitzbergen,' p. 6). The setting of fruits was observed by Kjellman in 1872–3 (according to Ekstam, op. cit.), and by T. M. Fries on Sept. 9, 1868 (Andersson and Hesselman, op. cit.).

VISITORS.—H. Müller observed a beetle, a fly, a Hymenopterid, and 10 Lepidoptera. Ekstam (20. 7. '97) noticed an undetermined fly in Spitzbergen.

1364. **E. speciosus** DC.—

VISITORS.—Loew saw the hover-fly Eristalis arbustorum *L.* in the Berlin Botanic Garden.

1365. **E. Villarsii** Bell. (Kirchner, 'Beiträge,' p. 66.)—According to Kirchner, who investigated this species at Zermatt, the heads agree essentially in their mechanism with those of E. alpinus.—About 100 female ray-florets, with their lilac-coloured tongues (3 mm. long), extend the diameter of the open inflorescence to about 15 mm. Within these come tubular female disk-florets in one or more series, while the middle of the disk is occupied by hermaphrodite florets, varying in number, and sometimes reduced to one.

427. Solidago L.

The mechanism of the disk-florets is similar to that described for Chrysocoma. Kerner states that ray-florets, as in Aster, are geitonogamously pollinated by the disk-florets.

1366. **S. Virgaurea** L. (Hildebrand, 'Ü. d. Geschlechtsverhält. u. d. Compositen,' pp. 22–3, *Taf. II, Figs.* 7–10; Warnstorf, *Verh. bot. Ver., Berlin*, xxxviii, 1896; Herm. Müller, 'Fertilisation,' pp. 320–1; Knuth, 'Blütenbiol. Herbstbeob.,' 'Bloemenbiol. Bijdragen.')—This species is gynomonoecious. The tongues of the golden-yellow female ray-florets are 5–7 mm. long; the stylar branches are almost devoid of sweeping-hairs, and are beset marginally and internally with stigmatic papillae. The diameter of the heads is 14–19 mm. Warnstorf states that the stigmas of the female ray-florets, and those of the outer row of hermaphrodite disk-florets become mature almost simultaneously. In the absence of insect visitors, pollen from the little heaps on the upper parts of the stylar branches may easily reach the margins of their lower stigmatic regions, and effect self-pollination. The pollen-grains are yellow in colour, rounded or ellipsoidal, covered with coarse spinose tubercles, up to 31 μ long and 23 μ broad.

VISITORS.—I observed the following.—

A. Diptera. (*a*) *Muscidae*: 1. Lucilia caesar *L.*, skg.; 2. Musca domestica *L.*, do. (*b*) *Syrphidae*: all po-dvg.: 3. Eristalis arbustorum *L.*; 4. E. nemorum *L.*; 5. E. pertinax *Scop.*; 6. E. tenax *L.*; 7. Syritta pipiens *L.*; 8. Syrphus sp. **B. Hymenoptera.** *Apidae*: 9. Apis mellifica *L.* ☿, skg. and po-cltg.; 10. Bombus lapidarius *L.* ♀, do.; 11. B. terrester *L.* ☿, do. **C. Lepidoptera.** *Rhopalocera*: 12. Epinephele janira *L.*, skg.

Herm. Müller gives the following.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, freq., po-dvg.; 2. E. nemorum *L.*, do. **B. Hymenoptera.** *Apidae*: 3. Andrena denticulata *K.* ♀ and ♂, po-cltg. and skg. (Borgstette); 4. Apis mellifica *L.* ♂, freq., skg.; 5. Bombus terrester *L.* ♂, skg.; 6. Psithyrus campestris *L.* ♂, skg.; 7. P. rupestris *L.* ♂, skg. **C. Lepidoptera.** *Rhopalocera*: 8. Thecla ilicis *Esp.*, skg. Also (Alps), a beetle, 22 flies, 6 bees, a true wasp, and 27 Lepidoptera ('Alpenblumen,' pp. 444–5).

Alfken observed the following bees at Bremen.—

1. Andrena denticulata *K.* ♂; 2. A. gwynana *K.* ♀, 2nd gen.; 3. Bombus agrorum *F.* ♂; 4. B. derhamellus *K.* ♂; 5. B. lapidarius *L.* ♂; 6. Halictus flavipes *F.* ♂; 7. H. leucozonius *Schr.* ♂.

Schletterer gives the following bees for the Tyrol.—

1. Andrena parvula *K.*; 2. Bombus mastrucatus *Gerst.*; 3. B. terrester *L.*; 4. Halictus albipes *F.*; 5. Psithyrus campestris *Pz.*; 6. P. globosus *Ev.*; 7. P. rupestris *F.*; 8. P. vestalis *Fourcr.*

The following were recorded by the observers, and for the localities stated.—

Schmiedeknecht (Thuringia), 2 bees (Bombus hypnorum *L.* ♂, and B. lapidarius *L.* ♂). Hoffer (Steiermark), 2 bees (Bombus lapidarius *L.* ♀, ☿, and ♂, and B. hypnorum *L.* ♂). Friese (Baden), 3 bees—1. Halictus calceatus *Scop.* ♂, not infrequent; 2. H. flavipes *F.* ♂, freq.; 3. Nomada solidaginis *Pz.*, do. Schenck (Nassau), 5 bees—1. Bombus confusus *Schenck* ♀ and ♂; 2. Halictus calceatus *Scop.* ♂; 3. H. flavipes *F.* ♂; 4. H. rubicundus *Chr.* ♂; 5. H. tetrazonius *Klg.* ♂. MacLeod (Pyrenees), a Syrphid and 3 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 359); (Flanders), Apis, 3 humble-bees, 5 short-tongued bees, an Ichneumonid, a fossorial wasp, 9 hover-flies, 9 Muscids, and 6 Lepidoptera (op. cit., v, 1893, pp. 414–15). Lindman (Dovrefjeld), flies, humble-bees and a Lepidopterid. Scott-Elliot (Dumfriesshire), a parasitic humble-bee and several flies ('Flora of Dumfriesshire,' p. 91).

1367. **S. canadensis** (L. Herm. Müller, 'Fertilisation,' p. 321, 'Weit. Beob.,' III, p. 292; Knuth, 'Bloemenbiol. Bijdragen.'—

Visitors.—Herm. Müller observed the following.—

A. Coleoptera. *Phalacridae*: 1. Phalacrus corruscus *Panz.*, occasional. **B. Diptera.** (*a*) *Muscidae*: 2. Calliphora erythrocephala *Mg.*; 3. Lucilia caesar *L.*; 4. L. cornicina *F.*; 5. Musca corvina *F.*; 6. M. domestica *L.*; 7. Sarcophaga carnaria *L.*, po-dvg.; 8. Numerous small species. (*b*) *Syrphidae*: 9. Cheilosia scutellata *Fall.*; 10. Eristalis arbustorum *L.*, freq., po-dvg.; 11. E. nemorum *L.*, do.; 12. E. pertinax *Scop.*; 13. E. tenax *L.*; 14. Helophilus floreus *L.*; 15. H. pendulus *L.*; 16. Syritta pipiens *L.*, freq., po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 17. Halictus cylindricus *F.* ♂, numerous; 18. H. zonulus *Sm.* ♀ and ♂, very numerous, skg., po-dvg. and po-cltg.; 19. Sphecodes gibbus *L.* ♀ and ♂, very numerous, skg. and po-dvg. (*b*) *Formicidae*: 20. Formica fusca *L.* ☿, very numerous. (*c*) *Sphegidae*: 21. Ammophila sabulosa *L.* ♀, skg.; 22. Pompilus niger *F.* ♀, skg. **D. Neuroptera.** 23. Panorpa communis *L.* in large numbers.

The following were recorded by the observers, and for the localities stated.—

Loew (Berlin Botanic Garden), 3 Muscids (1. Anthomyia sp.; 2. Echinomyia fera *L.*; 3. Pyrellia cadaverina *L.*) and 3 Syrphids (1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. Syrphus ribesii *L.*). Knuth, 3 Syrphids, skg. and po-dvg. (1. Eristalis arbustorum *L.*; 2. Helophilus pendulus *L.*; 3. Syritta pipiens *L.*). Alfken, the bee Andrena denticulata *K.*, very numerous on one occasion.

1368. **S. ambigua** Ait.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Echinomyia fera *L.*; 3. Pyrellia cadaverina *L.* (*b*) *Syrphidae*: 4. Eristalis nemorum *L.*; 5. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 6. Bombus terrester *L.* ♀, skg.

1369. **S. bicolor** L.—

Visitors.—Loew observed 2 Muscids (Calliphora erythrocephala *Mg.*, and Lucilia caesar *L.*) and a Syrphid (Syrphus balteatus *Deg.*) in the Berlin Botanic Garden.

1370. **S. caesia** L.—

Visitors.—Loew observed 2 Muscids (Anthomyia sp. and Onesia sepulcralis *Mg.*) and a Sphegid (Oxybelus uniglumis *L.* ♂) in the Berlin Botanic Garden.

1371. **S. carinata** Schrad.—

Visitors.—Loew saw the butterfly Vanessa c-album *L.*, skg., in the Berlin Botanic Garden.

1372. **S. Drummondii** Torr. et Gray.—

Visitors.—Loew saw a Sphegid (Ammophila sabulosa *L.*) and 2 Vespids (Eumenes coarctatus *L.*, and Odynerus parietum *L.*), in the Berlin Botanic Garden.

1373. **S. fragrans** Willd.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Lagriidae*: 1. Lagria hirta *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Calliphora vomitoria *L.*; 3. Echinomyia fera *L.*; 4. Onesia sepulcralis *Mg.*; 5. Pyrellia cadaverina *L.*; 6. Sarcophaga carnaria *L.*; 7. Sarcophila latifrons *Fall.* (*b*) *Syrphidae*: 8. Eristalis aeneus *Scop.*; 9. E. arbustorum *L.*; 10. E. nemorum *L.*; 11. E. tenax *L.*; 12. Helophilus floreus *L.*; 13. H. trivittatus *F.*; 14. Syritta pipiens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 15. Apis mellifica *L.* ☿, skg. and po-cltg.; 16. Bombus terrester *L.* ☿, skg.; 17. Halictus cylindricus *F.* ♀, skg. (*b*) *Sphegidae*: 18. Ammophila sabulosa *L.* (*c*) *Vespidae*: 19. Vespa crabro *L.* ☿; 20. V. germanica *F.*

1374. **S. glabra** Desf.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Chloria demandata *F.*; 3. Echinomyia fera *L.*; 4. Lucilia caesar *L.*; 5. Pyrellia cadaverina *L.*; 6. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 7. Eristalis arbustorum *L.*; 8. E. nemorum *L.*; 9. Helophilus floreus *L.*; 10. Syritta pipiens *L.*; 11. Syrphus balteatus *Deg.* **B. Hymenoptera.** *Apidae*: all skg.: 12. Halictus cylindricus *F.* ♂; 13. Prosopis armillata *Nyl.* ♀; 14. P. communis *Nyl.* ♀; 15. Sphecodes ephippius *L.* ♂. (*b*) *Sphegidae*: 16. Ammophila sabulosa *L.* ♀ and ♂; 17. Cerceris variabilis *Schr.* ♀; 18. Crabro vexillatus *Pz.* ♀; 19. Oxybelus bipunctatus *Oliv.* ♀; 20. O. uniglumis *L.* (*c*) *Vespidae*: 21. Odynerus parietum *L.*; 22. Vespa germanica *F.*

1375. **S. graminifòlia** Ell.—

Visitors.—Loew observed the Straphylinid beetle Xantholinus linearis *Oliv.* in the Berlin Botanic Garden.

1376. **S. juncea** Ait.—

Visitors.—Loew observed the Bibionid fly Dilophus vulgaris *Mg.* in the Berlin Botanic Garden.—

1377. **S. lateriflora** Ait.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Scarabaeidae*: 1. Cetonia aurata *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Calliphora erythrocephala *Mg.*; 3. Echinomyia fera *L.*; 4. Lucilia caesar *L.* (*b*) *Syrphidae*: 5. Syritta pipiens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 6. Bombus terrester *L.* ♂, skg.; 7. Prosopis communis *Nyl.* ♀, skg. (*b*) *Sphegidae*: 8. Ammophila sabulosa *L.* (*c*) *Vespidae*: 9. Vespa germanica *F.* **D. Lepidoptera.** *Rhopalocera*: 10. Epinephile janira *L.*

1378. **S. latifolia** L.—

Visitors.—Loew observed a Muscid (Anthomyia sp.) in the Berlin Botanic Garden.

1379. **S. lithospermifolia** Willd.—

Visitors.—Loew observed a Muscid (Anthomyia sp.) and a Vespid (Vespa germanica *F.*) in the Berlin Botanic Garden.

1380. **S. livida** Willd.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Muscidae*: 1. Anthomyia sp.; 2. Lucilia caesar *L.*; 3. Sarcophaga carnaria *L.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Halictus cylindricus *F.* ♂, skg.; 5. H. rubicundus *Chr.*, ♀, skg. and po-cltg.; 6. Prosopis communis *Nyl.* ♂, skg. (*b*) *Sphegidae*: 7. Crabro vexillatus *Pz.* ♀; 8. Oxybelus uniglumis *L.* ♂.

1381. **S. missouriensis** Nutt.—

Visitors.—Loew observed 4 Syrphids in the Berlin Botanic Garden—1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. tenax *L.*; 4. Helophilus floreus *L.*

1382. **S. ohiohensis** Riddell.—

Visitors.—Loew observed a Muscid (Anthomyia sp.) in the Berlin Botanic Garden.

1383. **S. Ridellii** Frank.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Spilogaster urbana *Mg.* (*b*) *Syrphidae*: 3. Syritta pipiens *L.*; 4. Syrphus balteatus *Deg.* **B. Hymenoptera.** (*a*) *Apidae*: 5. Halictus cylindricus *F.* ♂, skg.; 6. Prosopis communis *Nyl.* ♂, skg. (*b*) *Vespidae*: 7. Vespa germanica *F.*

1384. **S. rigida** L.—

Visitors.—Loew observed the following **Diptera** in the Berlin Botanic Garden.—

(*a*) *Muscidae*: 1. Anthomyia sp. (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*; 3. E. nemorum *L.*; 4. Helophilus floreus *L.*; 5. Syritta pipiens *L.*

1385. **S. ulmifolia** Muhl.—

Visitors.—Loew observed a Muscid (Anthomyia sp.) and a Vespid (Vespa germanica *F.*) in the Berlin Botanic Garden.

428. Micropus L.

Kerner states that there are purely female florets in addition to pseudo-hermaphrodite pollen-florets, but none which are truly hermaphrodite.

429. Telekia Baumg.

Clavate end of the style with sweeping-hairs; stigmatic papillae occupying a longitudinal groove on the inner side of each branch.

1386. **T. speciosa** Baumg. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 24–5, Taf. II, Figs. 16–17; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 191, 322.)—In this species the disk-florets are at first yellow in colour, but afterwards turn brown. Kerner states that the common receptacle is flat to begin with, but becomes raised in the course of anthesis, so that the receptive stigmas of the outer florets are brought into the line of fall of the pollen of the inner ones.

430. Buphthalmum L.

1387. **B. salicifolium** L. (=B. grandiflorum *L.*).—As No. 1386.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 3 flies, 6 Hymenoptera, and 6 Lepidoptera ('Alpenblumen,' p. 444). Schiner (Austria), the Bombyliid Exoprosopa cleomene *Egg.*, and the Conopid Myopa variegata *Mg.*, occasional.

431. Dahlia Cav.

The stylar branches are covered externally with sweeping-hairs, extending from about half-way down to their tips, and longest in the middle. Stigmatic papillae in two marginal rows.

1388. **D. variabilis** Desf. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 19–20, Taf. I, Figs. 26–9.)—The female ray-florets of this species usually possess vestigial stamens.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (on unfertilized heads in the Botanic Garden of the Kiel Ober-Realschule; 10. 9. 97), numerous honey-bees, which while nect-skg. covered their under-sides with pollen ('Blütenbiol. Notizen'). Alfken (Bremen), 4 humble-bees—1. Bombus agrorum *F.* ♀ and ♂; 2. B. lapidarius *L.* ♂; 3. B. ruderatus *F.* ♂; 4. B. terrester *L.* ♂.

1389. **D. Cervantesii** Lag.—

Visitors.—Loew observed a hover-fly (Syrphus balteatus *Deg.*) and a humble-bee (Bombus terrester *L.* ♂), both skg., in the Berlin Botanic Garden.

432. Silphium L.

1390. **S. Asteriscus** L.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*; 2. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.; 4. Bombus terrester *L.* ♂, skg.; 5. Halictus leucozonius *Schr.* ♀, do.; 6. H. sexnotatus *K.* ♀, do. **C. Lepidoptera.** *Rhopalocera*: 7. Rhodocera rhamni *L.*; 8. Pieris brassicae *L.*, skg.

1391. **S. connatum** L.—

Visitors.—Loew observed a hover-fly (Eristalis nemorum *L.*), a humble-bee (Bombus terrester *L.* ♂, skg.), and a butterfly (Pieris brassicae *L.*, skg.) in the Berlin Botanic Garden.

1392. S. dentatum Ell.—

Visitors.—Loew observed the hover-fly Eristalis tenax *L.* in the Berlin Botanic Garden.

1393. S. erythrocaulon Bernh.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. E. tenax *L.*; 3. Melithreptus scriptus *L.* **B. Hymenoptera.** *Apidae*: 4. Apis mellifica *L.* ☿, skg. and po-cltg.; 5. Bombus terrester *L.* ♂, skg.

1394. S. gummiferum Ell.—

Visitors.—Loew observed a hover-fly (Eristalis tenax *L.*) and a humble-bee (Bombus terrester *L.* ♂, skg.) in the Berlin Botanic Garden.

1395. S. perfoliatum L.—Sprengel says that insects creeping into the florets of this species 'push the anthers in front of them into the flower,' so that the pollen-covered stylar brushes are caused to protrude ('Entd. Geh.,' pp. 383–4).

Visitors.—Loew observed a hover-fly (Eristalis tenax *L.*) and a butterfly (Pieris brassicae *L.*, skg.) in the Berlin Botanic Garden.

1396. S. terebinthinaceum L.—

Visitors.—Loew observed 2 hover-flies (Eristalis tenax *L.*, and Syrphus ribesii *L.*) in the Berlin Botanic Garden.

1397. S. trifoliatum L.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Chrysomelidae*: 1. Cassida nebulosa *L.* **B. Hymenoptera.** 2. Apis mellifica *L.* ☿, skg. and po-cltg.; 3. Bombus terrester *L.* ♂, skg.; 4. Psithyrus vestalis *Fourcr.* ♂, do.

433. Inula L.

Ray-florets uniseriate, female; disk-florets hermaphrodite.

Kerner says that many of the Inulas growing side by side in the Black Sea region—I. Oculus-Christi *L.*, I. ensifolia *L.*, I. germanica *L.*, I. salicina *L.* and so on—during the summer 'blossom in definite succession, so that one species always begins to fade when another is in its prime. Each capitulum of these Inulas consists of tongue-shaped pseudo-hermaphrodite florets on the circumference and tubular hermaphrodite florets in the centre. The former unfold earlier than the latter, and for each of these species there is a certain period, if only two days, when the pollen, brought by insects to the stigmas of the pistillate flowers in the circumference, can only have been obtained from another species, since their own pollen is not obtainable.'

1398. I. hirta L. (Herm. Müller, 'Weit. Beob.,' III, p. 91, 'Nat. Hist. Pl., Eng. Ed. 1, II, p. 316.)—Hermann Müller states that in this species about 200 dark-yellow tubular florets, expanding into narrow bells, make up a disk 13–15 mm. in diameter. They are surrounded by about 50 golden-yellow ray-florets with tongues 15 mm. long. The star-like head thus constituted is 40–45 mm. in diameter. The tube of the disk-florets is 3–3½ mm. in length; the bell 2 mm. long and 1 mm. broad. As the nectar rises as far as the bell, it is accessible even to very short-tongued

insects. The stylar branches project 1 mm. from the disk-florets, and diverge at an angle of 45–60°.

VISITORS.—Herm. Müller observed the following in Thuringia.—

A. Coleoptera. *Cerambycidae*: 1. Strangalia bifasciata *Müll.*, gnawing the anthers. **B. Diptera.** (*a*) *Empidae*: 2. Empis sp., skg. (*b*) *Muscidae*: 3. Aricia sp., skg. **C. Hymenoptera.** (*a*) *Apidae*: 4. Coelioxys conoidea *Ill.* ♂, skg.; 5. Megachile centuncularis *L.*, ♂, do.; 6. Nomada ruficornis *L.* ♀, do.; 7. Osmia spinulosa *K.* ♀, extremely numerous, actively po-cltg.; 8. Stelis breviuscula *Nyl.* ♀, skg. (*b*) *Tenthredinidae*: 9. Tarpa cephalotes *F.*, freq., skg. **D. Lepidoptera.** *Rhopalocera*: 10. Coenonympha pamphilus *L.*, skg.; 11. Melitaea athalia *Rott.*, very common, skg.; 12. Thecla ilicis *Esp.*, skg.

1399. **I. Helenium** L. (Herm. Müller, 'Weit. Beob.,' III, p. 91.)—

VISITORS.—Buddeberg observed the following in Nassau.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, po-dvg.; 2. Volucella inanis *L.*, do. **B. Hymenoptera.** *Apidae*: 3. Anthidium manicatum *L.*, ♂, skg. (?); 4. Andrena minutula *K.* ♀, do.; 5. Chelostoma nigricorne *Nyl.* ♂, do.; 6. Coelioxys rufescens *Lep.* ♀ and ♂, do.; 7. Epeolus variegatus *L.*, do.; 8. Halictus leucopus *K.* ♂, do.; 9. H. sexcinctus *F.* ♀ and ♂, po-cltg. and skg.; 10. H. tetrazonius *Klg.* ♀, do.; 11. Osmia claviventris *Thoms.* ♀, do.; 12. Stelis aterrima *Pz.* ♀ and ♂, very numerous, skg.; 13. S. phaeoptera *K.* ♀, occasional, skg.

Handlirsch, on the authority of Assmuss, records the fossorial wasp, Alyson fuscatus *Pz.*

1400. **I. britannica** L. (Herm. Müller, 'Weit. Beob.,' III, p. 92.)—

VISITORS.—Buddeberg observed the following in Nassau.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*, po-dvg. **B. Hymenoptera.** *Apidae*: 2. Anthidium manicatum *L.* ♂, skg.; 3. Epeolus variegatus *L.* ♀ and ♂, do.; 4. Panurgus calcaratus *Scop.* ♀ and ♂, skg. and po-dvg.

Alfken (Bremen) noticed the parasitic humble-bee Psithyrus vestalis *Fourcr.* ♀, skg. Loew (Berlin Botanic Garden) records the bug Eurygaster maura *L.*

1401. **I. salicina** L. (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In this species the stigmas of the female ray-florets are still receptive when the outer hermaphrodite disk-florets open, so that geitonogamy without the help of insects is easily possible. The stylar branches of the tubular florets are flattened, and somewhat enlarged apically, so that as long as they remain apposed in the anther-cylinder they form a clavate terminal expansion by which the pollen is pushed out. Sweeping-hairs are only present in very small numbers at the extreme tip, and owing to the peculiar construction of the stylar branches are almost superfluous. Internally these branches are beset with very short stigmatic papillae, and ultimately diverge to an angle as much as 90°, but without becoming reflexed. Since they are relatively long, the pollen of younger florets can easily reach the stigmas of older ones, and thus effect geitonogamy in the absence of insect visitors. The pollen-grains are yellow in colour, polyhedral, with marginal spinose tubercles, about 22 μ in diameter.

VISITORS.—Loew (Brunswick) observed the moth Zygaena onobrychis *S. V.*, skg. ('Beiträge,' p. [illegible])

1402. I. thapsoides DC.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. Syrphus ribesii *L.* **B. Hemiptera.** 4. Aelia acuminata *L.*

1403. I. viscosa Ait. (=Cupularia viscosa *Godr. et Gren.*).—

VISITORS.—Delpino observed Pieris, Vanessa, and other butterflies ('Ult. oss.,' Atti soc. ital. sc. nat., xvi, 1873).

1404. I. ensifolia L.—

VISITORS.—Schiner (Austria) observed the fly Myopites inulae *v. Roser.*

1405. I. Conyza DC. (=Conyza squarrosa *L.*).—

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Schenck (Nassau), the leaf-cutting bee Megachile centuncularis *L.* Schiner (Austria), the fly Tephritis zelleri *Loew.* Schletterer and von Dalla Torre (Tyrol), the bee Halictus sexcinctus *F.*

434. Pulicaria Gaertn.

Ray-florets uniseriate, female; disk-florets tubular, hermaphrodite. Stylar branches beset with stigmatic papillae over their entire inner surfaces; the upper third of their outer surface covered with sweeping-hairs directed obliquely upwards.

1406. P. dysenterica Gaertn. (=Inula dysenterica *L.*). (Herm. Müller, 'Fertilisation,' pp. 324–6, 'Weit. Beob.,' III, p. 90; Giard, Bot. Jaarb. Dodonaea, Ghent, ii, 1890, pp. 334–7; Knuth, 'Bloemenbiol. Bijdragen.')—This species is gynomonoecious. Upwards of 600 yellow disk-florets are surrounded by about 100 ray-florets of the same colour. Hermann Müller states that the corolla-tube is about 4 mm. long. Only the stylar branches (about ½ mm. in length) project from the anther-cylinder. These branches spread out horizontally and become recurved, so that the stigmas occupy the place where pollen was to be found in the first (male) stage. Hence insect visitors creeping about on the head pollinate simultaneously numerous florets in the female stage. The triangular valves forming the upper ends of the anthers are fringed with hairs, which are much longer and thicker than the sweeping-hairs: they hold the pollen pressed out of the anther-cylinder.

At Boulogne (Pas-de-Calais) Giard (1877) found several plants bearing abnormal heads, some female and devoid of a ray, others male with an imperfect one. The florets contained either vestigial stamens or vestigial pistils, and were degenerate in other respects. For ten years in succession Giard removed all the normal stocks from this station, and so converted the originally gynomonoecious plant into a purely dioecious one.

VISITORS.—I only saw the butterfly Vanessa urticae *L.*, skg.

Herm. Müller observed the following.—

A. Coleoptera. *Chrysomelidae*: 1. Cassida murraea *L.*, not infrequent, creeping over the heads. **B. Diptera.** *Syrphidae*: 2. Eristalis arbustorum *L.*, very common, po-dvg.; 3. E. sepulcralis *L.*, do.; 4. Melithreptus scriptus *L.*, po-dvg.; 5. Syritta

pipiens *L.*, do. **C. Hymenoptera.** *Apidae*: 6. Halictus albipes *F.* ♂, skg.; 7. H. cylindricus *F.* ♂, do.; 8. H. longulus *Sm.* ♂, do.; 9. H. maculatus *Sm.* ♂, do.; 10. H. nitidus *Schenck* ♂, do.; 11. Heriades truncorum *L.* ♀ and ♂, very numerous. **D. Lepidoptera.** *Rhopalocera.* 12. Hesperia thaumas *Hfn.*, skg.; 13. Lycaena sp.; 14. Polyommatus dorilis *Hfn.*

MacLeod (Flanders) noticed the bee Halictus, 6 hover-flies, and 3 Muscids (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 416).

Burkill observed the following on the East coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Nitidulidae*: 1. Meligethes aeneus *F.*, dvg. and almost completely covered with pollen; 2. M. obscurus *Er.*; 3. M. picipes *Sturm.*; 4. M. viridescens *F.*, as M. aeneus. **B. Diptera.** (*a*) *Muscidae*: 5. Anthomyia brevicornis *Zett.*, po-dvg.; 6. A. radicum *L.*, very common, po-dvg.; 7. Calliphora erythrocephala *Mg.*; 8. Coelopa sp., po-dvg.; 9. Drymeia hamata *Fall.*, skg. and po-dvg.; 10. Hylemyia strigosa *F.*; 11. Lucilia cornicina *F.*; 12. Morellia sp.; 13. Phorbia lactucae *Bouché*, po-dvg.; 14. Scatophaga stercoraria *L.*; 15. Siphona geniculata *Deg.*, freq., skg. and po-dvg. (*b*) *Syrphidae*: 16. Eristalis arbustorum *L.*; 17. E. pertinax *Scop.*, skg.; 18. E. tenax *L.*, do.; 19. Platycheirus albimanus *F.*; 20. P. manicatus *Mg.*; 21. Sphaerophoria scripta *L.*; 22. Syritta pipiens *L.*; 23. Syrphus ribesii *L.* **C. Hymenoptera.** (*a*) *Apidae*: 24. Bombus lapidarius *L.*, skg. (*b*) *Ichneumonidae*: 25. 2 undetermined species. **D. Lepidoptera.** *Microlepidoptera*: 26. Plutella xylostella *L.*, skg.; 27. Simaëthis fabriciana *Steph.*, do. **E. Thysanoptera.** 28. Thrips sp.

(*c*) Tribe *Senecionideae* Less.

Styles of the hermaphrodite florets cylindrical, with linear penicillate branches fulcrate at the tip.

435. Xanthium L.

Male and female florets in different heads on the same stock. Male florets with vestigial styles (Kirchner). Female florets open much earlier than male ones (Kerner).

436. Helenium L.

1407. H. autumnale L.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. E. tenax *L.*; 3. Helophilus floreus *L.*; 4. Syrphus balteatus *Deg.* **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, skg. and po-cltg.; 6. Halictus cylindricus *F.* ♂, skg.; 7. H. rubicundus *Chr.* ♀, skg. and po-cltg.; 8. Heriades truncorum *L.* ♀, po-cltg. **C. Lepidoptera.** *Rhopalocera*: 9. Pieris brassicae *L.*, skg.; 10. P. rapae *L.*, skg.

1408. H. californicum Link.—

Visitors.—Loew noticed Apis, skg. and po-cltg., in the Berlin Botanic Garden.

1409. H. decurrens Vatke.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*; 2. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.; 4. Heriades truncorum *L.* ♀, po-cltg.

437. Bidens L.

Ray-florets sometimes absent in German species; ligulate, neuter, coloured like the hermaphrodite tubular disk-florets. Stylar branches with lancet-shaped tips, covered externally by strong sweeping-hairs, and beset with numerous stigmatic papillae internally.

1410. **B. tripartita** L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' p. 67, Taf. I, Figs. 30–1; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 416–17; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 88, 157.)—Ray-florets are almost always wanting in this species. The diameter of the head is at most 1 cm. The sweeping-hairs at the tip of the style are moderately long, the next below are shorter, and the lowest are the longest. They brush out the pollen from the anther-cylinder, which afterwards becomes completely retracted into the corolla-tube. The stylar branches then unfold their papillose inner sides; the corolla-lobes so far spread out at the same time resume a nearly vertical position; and the pappus bristles, with deflexed prickles on their outer sides, spread out so that the diameter of the head is ultimately increased to $2\frac{1}{2}$ cm. The florets are at first yellow, but towards the end of anthesis assume an inconspicuous brown colour.

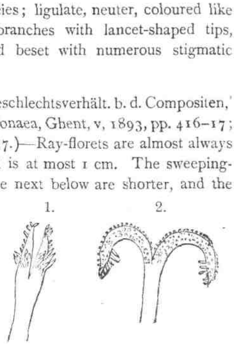


FIG. 197. *Bidens tripartita*, *L.* (from nature). (1) Tip of style, with sweeping-hairs, in opening floret. (2) Ditto, of floret in female stage: stylar branches recurved, and beset with stigmatic papillae internally. (× 20.)

VISITORS.—MacLeod (Belgium) saw 2 bees (Bombus and Andrena).

I noticed at Kiel 3 hover-flies (1. Melithreptus taeniatus *Mg.*; 2. Platycheirus manicatus *Mg.*; 3. Syrphus balteatus *Deg.*), and a bug (Calocoris bipunctatus *F.*).

1411. **B. cernua** L. (Herm. Müller, 'Weit. Beob.,' III, p. 88; MacLeod, op. cit.; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Herbstbeob.')—In this species about 100 yellow florets are aggregated into a head. Hermann Müller states that each disk-floret has a corolla-tube about $1\frac{1}{2}$ mm. long, with a bell of about the same length and 1 mm. in width. In the first stage of anthesis the pollen-covered anther-cylinder projects about 1 mm. from the bell, and in the second stage the stylar branches (also 1 mm. long) diverge. The mechanism of these branches agrees with that described for B. tripartita. The stigmatic papillae are so broad that pollen-grains of the same flower may readily remain adhering on the margin, so that automatic self-pollination is possible, as it is also in the last species. There are three varieties.—

(*a*) *discoidea* Wimm.; ray-florets absent;

(*b*) *radiata* DC. (=Coreopsis Bidens *L.*); large ray-florets;

(*c*) *minima* L. (=B. minima *L.*); plant low (stem only 4–10 cm. high); usually only one small head.

VISITORS.—Herm. Müller saw only the honey-bee at Lippstadt.

At Kiel I observed a humble-bee (Bombus terrester *L.* ♀, skg.) and a Muscid (Lucilia cornicina *F.*, po-dvg.).

438. Actinomeris Nutt.

1412. A. helianthoides Nutt.—

Visitors.—Loew saw the bee Bombus lapidarius *L.* ♂, skg., in the Berlin Botanic Garden.

439. Boltonia L'Hérit.

1413. B. glastifolia L'Hérit.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp.; 2. Lucilia sylvarum *Mg.*; 3. Pyrellia cadaverina *L.* (*b*) *Syrphidae*; 4. Eristalis arbustorum *L.*; 5. E. nemorum *L.*; 6. E. tenax *L.*; 7. Helophilus floreus *L.*; 8. Melithreptus scriptus *L.*; 9. Syritta pipiens *L.*; 10. Syrphus ribesii *L.* **B. Hymenoptera.** (*a*) *Apidae*: 11. Apis mellifica *L.*, skg. (*b*) *Vespidae*: 12. Vespa germanica *F.* **C. Lepidoptera.** *Rhopalocera*: 13. Vanessa urticae *L.*, skg.

440. Helianthus L.

Ray-florets neuter; disk-florets hermaphrodite.

1414. H. annuus L. (Sprengel, 'Entd. Geh.,' pp. 378–80.) In this species the diameter of the heads is as much as $\frac{1}{3}$ m. The ray-florets are yellow in colour, the disk-florets are brown.

Visitors.—Alfken observed the following bees at Bremen.—

1. Bombus agrorum *F.* ♂; 2. B. hortorum *L.* ♀, skg.; 3. B. hypnorum *L.* ♂; 4. B. lapidarius *L.* ♂; 5. B. pomorum *Pz.* ♂; 6. B. ruderatus *F.* ♂, skg.; 7. B. sylvarum *L.* ♀ and ♂, do.; 8. B. terrester *L.* ☿; 9. Coelioxys acuminata *Nyl.* ♀, do.; 10. Megachile circumcincta *L.* ♀; 11. Psithyrus campestris *Pz.* ♂; 12. P. rupestris *F.* ♂. Also (Bozen), the bee Xylocopa violacea *L.* ♀, occasional, skg.; and the Pentatomid Carpocoris baccarum *L.*, freq., skg. The former was seen flying from one head to another as late as 10 p.m.

The following were recorded by the observers, and for the localities stated.—

Knuth, 3 bees, skg. and po-cltg. (1. Apis mellifica *L.* ☿; 2. Bombus lapidarius *L.*; 3. B. terrester *L.* ♀ and ☿), 2 flies, po-dvg. (Eristalis sp. and Pollenia rudis *F.*), 2 Hemiptera (Calocoris bipunctatus *F.* and Lygus pabulinus *L.*), and an earwig (Forficula auricularia *L.*, dvg. the florets). Sprengel also records the earwig as a common visitor. Sickmann (Osnabrück), the Pompilid Pseudagenia carbonaria *Scop.*, rare. Schletterer (Tyrol), the bee Halictus alternans *Ill.*

1415. H. multiflorus L.—In this species the pollen projects from the anther-cylinder during the first stage of anthesis, and the stylar branches during the second stage.

Visitors.—The following were recorded by the observers named.—

Delpino the bee Heriades truncorum *L.* Herm. Müller, 2 bees (Megachile centuncularis *L.*, po-cltg., and Halictus zonulus *Sm.* ♀, skg. and po-dvg., and 3 hover-flies), skg. and po-dvg. (1. Eristalis tenax *L.*; 2. Syrphus pyrasti *L.*; 3. S. ribesii *L.*).

1416. H. atrorubens L.—

Visitors—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. E. tenax *L.*; 3. Syrphus balteatus *Deg.* **B. Hymenoptera.** *Apidae*: 4. Apis mellifica *L.* ☿, skg. and po-cltg.; 5. Bombus terrester *L.* ♂, skg.; 6. Psithyrus vestalis *Fourcr.* ♂, do.

1417. H. decapetalus Darl.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus balteatus *Deg.* **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg. and po-cltg.; 3. Bombus pratorum *L.* ♂, skg.; 4. B. terrester *L.* ☿, do.

1418. H. divaricatus *F.*—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. Melithreptus scriptus *L.*; 3. Syritta pipiens *L.*; 4. Syrphus corollae *F.* **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, skg. and po-cltg. **C. Lepidoptera.** *Rhopalocera*: 6. Pieris brassicae *L.*, skg.

1419. H. lactiflorus Pers.—

Visitors.—Loew observed the hover-fly Eristalis tenax *L.* in the Berlin Botanic Garden.

1420. H. Maximiliani Schrad.—

Visitors.—Loew observed 2 bees (Apis mellifica *L.* ☿, skg. and po-cltg.; Bombus terrester *L.* ☿, skg.) in the Berlin Botanic Garden.

1421. H. mollis Lam.—

Visitors.—Loew observed 2 bees, skg. (Bombus pratorum *L.* ♂, and B. terrester *L.* ♀ and ♂) in the Berlin Botanic Garden.—

1422. H. trachelifolius Mill.

Visitors.—Loew observed 2 hover-flies (Eristalis tenax *L.* and Helophilus trivittatus *F.*) in the Berlin Botanic Garden.

441. Echinacea Moench.

1423. E. purpurea Moench.—

Visitors.—Loew observed the humble-bee Bombus terrester *L.* ♂, skg., in the Berlin Botanic Garden.

442. Heliopsis Pers.

1424. H. laevis Pers.—

Visitors.—Loew observed 3 bees (1. Bombus pratorum *L.* ♂, skg.; 2. B. terrester *L.* ♂, do.; 3. Halictus sexnotatus *K.* ♀, do.) in the Berlin Botanic Garden.

1425. H. scabra Dun.—

Visitors.—Loew observed a Muscid (Calliphera vomitoria *L.*) and a humble-bee (Bombus terrester *L*, ☿, skg.) in the Berlin Botanic Garden.

1426. H. patula Wender.—

Visitors.—Schletterer (Tyrol) records the humble-bee Bombus confusus *Schenck*; and von Dalla Torre (Innsbruck Botanic Garden) the bee Trypetes truncorum *L.* ♀ and ♂.

443. Chrysostemma Less.

1427. C. tripteris Less.—

Visitors.—Loew observed a hover-fly (Eristalis tenax *L.*) and a butterfly (Pieris brassicae *L.*, skg.) in the Berlin Botanic Garden.

444. Coreopsis L.

1428. **C. auriculata** L.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Echinomyia fera *L.*; 2. Graphomyia maculata *Scop.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. Syritta pipiens *L.*; 5. Syrphus luniger *Mg.*; 6. S. ribesii *L.* **B. Hymenoptera.** *Apidae*: 7. Halictus cylindricus *F.* ♂, skg.

1429. **C. lanceolata** L.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Echinomyia fera *L.* (*b*) *Syrphidae*: 2. Eristalis nemorum *L.*; 3. E. tenax *L.*; 4. Melithreptus scriptus *L.*; 5. Syritta pipiens *L.*; 6. Syrphus balteatus *Deg.*; 7. S. corollae *F.* **B. Lepidoptera.** (*a*) *Noctuidae*: 8. Plusia triplasia *L.*, skg. (*b*) *Rhopalocera*: 9. Pieris brassicae *L.*, skg.

445. Rudbeckia L.

Ray-florets elongated, ligulate, neuter; disk-florets hermaphrodite.

1430. **R. laciniata** L. (Knuth, 'Blütenbiol. Herbstbeob.,' 'Bloemenbiol. Bijdragen.')—

VISITORS.—I observed 2 humble-bees, skg. (Bombus lapidarius *L.*, and B. terrester *L.*), a hover-fly (Syritta pipiens *L.*), and a Muscid (Pollenia vespillo *F.*) in the Botanic Garden of the Kiel Ober-Realschule.

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*; 2. Helophilus floreus *L.*; 3. Syritta pipiens *L.*; 4. Syrphus balteatus *Deg.*; 5. S. corollae *F.* **B. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.* ☿, skg. and po-cltg.; 7. Bombus terrester *L.* ♂, skg.; 8. Chelostoma nigricorne *Nyl.* ♀, po-cltg.; 9. Coelioxys elongata *Lep.* ♀, skg.; 10. Heriadas truncorum *L.* ♀, po-cltg.; 11. Megachile centuncularis *L.*, ♀, do.

1431. **R. speciosa** Wender.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Pyrellia cadaverina *L.* (*b*) *Syrphidae*: 2. Helophilus floreus *L.*; 3. Syritta pipiens *L.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Apis mellifica *L.* ☿, po-cltg.; 5. Halictus sexnotatus *K.* ♀, skg. (*b*) *Vespidae*: 6. Eumenes coarctatus *L.* **C. Lepidoptera.** *Rhopalocera*: 7. Pieris brassicae *L.*, skg.

446. Filago L.

Ray-florets filiform, in two or more series, female; disk-florets tubular, hermaphrodite.

1432. **F. minima** Fries. (Knuth, 'Bloemenbiol. Bijdragen.')—The heads of this species are yellowish-white in colour.

VISITORS.—I saw a hover-fly (Melanostoma mellina *L.*).

447. Antennaria Gaertn.

Dioecious. Styles of the male florets without stigmatic papillae, but densely covered with sweeping-hairs above; styles of the female florets with few hairs, but possessing a line of stigmatic papillae internally on each side.

1433. **A. dioica** Gaertn. (=Gnaphalium dioicum *L.*). (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 40–2, Taf. III, Figs. 26–32; Herm. Müller, 'Alpenblumen,' p. 436; Lindmann, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; Kirchner, 'Flora v. Stuttgart,' p. 703; Knuth, 'Bloemenbiol. Bijdragen.')—This species is dioecious. The white or rose-coloured involucral bracts render the heads conspicuous. The female florets are filiform, the male ones tubular; both kinds contain nectar. Hildebrand states that the ovary of male florets contains no ovule, while the style divides into two short blunt branches, devoid of stigmatic papillae; on the other hand, the whole upper part of the style is covered with sweeping-hairs, those at the tip being longest. The corolla, tubular below, ends in a bell with somewhat recurved lobes. The filaments are irritable, and curve when touched. In this way the anther-cylinder is retracted, so that pollen protrudes from its upper end. The corolla-tube of female flowers is long and narrow. The style projects beyond it, and the branches of this are externally covered with short hairs at their tips only, while their inner surfaces possess a line of stigmatic papillae on either side.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Lindmann (Dovrefjeld), a few Lepidoptera. Herm. Müller (Alps), a hover-fly, a fossorial wasp, and 9 Lepidoptera. Knuth (Tondern), a po-dvg. hover-fly (Eristalis tenax *L.*) and a butterfly, skg. MacLeod (Pyrenees), 2 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 363).

1434. **A. margaritacea** R. Br. (=Gnaphalium marginatum *L.*).—

Visitors.—I observed (12. 9. '97), 2 po-dvg. hover-flies (Eristalis tenax *L.*, and E. intricarius *L.*), 2 beetles (Coccinella quinquepunctata *L.*, and C. quattuordecimpunctata *L.*), and Thrips.

1435. **A. alpina** Gaertn. (=Gnaphalium alpinum *L.*).—This northern species is dioecious. According to Hartman ('Handbok i. Skand. Flora,' p. 7), Laestadius found male plants in 1842. Vahl, Lange, and Warming do not know of any such, but on the contrary suppose the species to be parthenogenetic, as it has been observed to set fruits in various localities.

The specimens collected by Dr. von Drygalski's Greenland expedition were all female (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' p. 65).

According to Juel ('Vergleich. Untersuch. ü. typische u. parthenogenet. Fortpfl. b. d. Gatt. Antennaria,' pp. 12–13), male stocks are extremely rare in Lapland and Norway: their florets usually contain a small quantity of functionless pollen or none at all. Reproduction is parthenogenetic. Juel (op. cit., p. 14) considers that the existence of male stocks is due to atavism: but he also thinks it possible that A. alpina may really be a hybrid, perhaps the result of crossing between A. dioica *Gaertn.* and A. monocephala *DC.*

448. Gnaphalium L.

Ray-florets female, filiform, in several series; disk-florets hermaphrodite and tubular; the tip of the style covered with tufted sweeping-hairs.

1436. **G. Leontopodium** L. (=Leontopodium alpinum *Cass.*). (Herm. Müller, 'Alpenblumen,' pp. 434–6; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II; MacLeod,

'Pyreneënbl.,' p. 363.)—*This species is monoecious. Twenty to thirty male disk-*florets with a considerably larger number of female ray-florets are aggregated into a head 4 mm. in diameter. Conspicuousness is enhanced by the cauline leaves, which are covered with a thick white hairy coat and surround the corymb of tiny heads to form a whitish star of 20 to 40 or 50 mm. in diameter.

The ray-florets possess a narrow corolla-tube $2\frac{1}{2}$–3 mm. in length, and secreting no nectar. The style, of which the branches are closely beset with stigmatic papillae internally, projects 1 mm. from it. The style is covered externally with short sweeping-hairs for some distance below the point where it divides. In male flowers the style does not bifurcate, and therefore possesses no trace of stigmatic papillae. It is in the form of a cylindrical rod covered with papillose sweeping-hairs at its end, and serving to brush out the pollen from the anther-cylinder. These pseudo-hermaphrodite male florets possess a

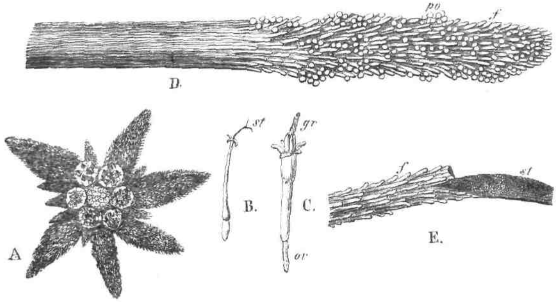


FIG. 198. *Gnaphalium Leontopodium*, L. (after Herm. Müller). *A.* Group of seven heads (nat. size). *B.* Female ray-floret without the pappus (× 7). *C.* Male disk-floret, do. (× 7). *D.* End of the style of a male floret, which acts as a brush (× 80). *E.* Do. of a female floret (× 80). *f*, sweeping-hairs; *gr*, style; *ov*, ovary; *po*, pollen-grains; *st*, stigmatic papillae.

corolla-tube about 2 mm. in length, expanding into a bell scarcely 1 mm. long, from which the anthers and style project. Nectar is secreted at the base of the style. Schröter describes nectar-florets, which resemble the male ones. They possess a vestigial rudimentary style with quite short sweeping-hairs, but no stamens (Ber. Schweiz. Bot. Ges., v, 1895, p. 5).

Kerner states that the stigmas of the female florets become receptive several days before the pollen of the neighbouring pseudo-hermaphrodite male florets is shed.

According to MacLeod, the species appears in the Pyrenees in the sub-alpine and lowest mountain region, where it possesses a considerably different habit. It is there more vigorous; the heads are more numerous, and more loosely aggregated; and the woolly leaves which surround the entire inflorescence are relatively longer.

VISITORS.—These are very few. MacLeod saw a Muscid: Herm. Müller observed a beetle, a Muscid, and Thrips.

1437. G. luteo-album L. (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Warnstorf says that the numerous narrow, tubular, female ray-florets of this species mature their stigmatic branches before the few (8–10) hermaphrodite disk-florets open; and that they elongate after pollination so as once more to completely enclose the stigmas. Geitonogamy is only possible between the inner female florets and the outer hermaphrodite ones. The pollen-grains are yellow in colour, rounded, with long spines, on an average 25 μ in diameter.

VISITORS.—Herm. Müller observed the following at Lippstadt ('Fertilisation,' p. 324).—

A. Diptera. *Muscidae*: 1. Lucilia, in large numbers; 2. Pollenia rudis *F.*, po-dvg. *Syrphidae*: 3. Melanostoma mellina *L.*, po-dvg.; 4. Melithreptus scriptus *L.*, do. **B. Hymenoptera.** (*a*) *Apidae*: 5. Halictus quadrinotatus *Schenck* ♂ and ♀, skg.; 6. Sphecodes gibbus *L.*, ♂ and ♀, different varieties, also S. ephippius *L.*, skg. (*b*) *Sphegidae*: 7. Ceropales maculatus *F.*, skg.; 8. Pompilus viaticus *L.*, do.

1438. G. sylvaticum L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 89; Kirchner, 'Beiträge,' p. 66.)—The elongated heads of this species are arranged in a spike, and are but slightly conspicuous. Kirchner describes them as 5–6 mm. long, with a diameter above of only 1½–2 mm. Each contains 60–70 female florets, and a few (usually only 3–4) hermaphrodite ones. In both of these the corolla is 4 mm. in length, and there is no difference in the form of the pistil: it contains one ovule, and there is an annular nectary at the base of the style. The style of the female florets is glabrous, and its two curved stigmatic branches, which are thin and moderately long, spread out above the corolla-tube. The upper end of the style of hermaphrodite florets is covered with sweeping-hairs. These brush out the pollen, and the two stylar branches then diverge, so that the stigmatic papillae of their inner surfaces become visible.

As I observed in the North Frisian Islands, either automatic self-pollination or geitonogamy may now occur, for the spinose pollen-grains still clinging to the sweeping-hairs may fall upon the stigmas of the same or neighbouring florets.

VISITORS.—A Muscid was recorded in Dumfriesshire (Scott-Elliot, 'Flora of Dumfriesshire,' p. 92).

1439. G. uliginosum L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 89; Kirchner, 'Beiträge,' p. 66.)—The heads of this species are of a rounded ovoid shape, 1½–2 mm. in diameter above, and aggregated into crowded leafy clusters. The individual florets are also only 1½–2 mm. long. Kirchner counted rather more than 100 female florets, and usually 6 hermaphrodite ones in each head: I have observed only about 30. The flower mechanism otherwise agrees with that of the last species.

According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), the tips of the involucral bracts of the small heads project somewhat beyond the female ray-florets, pressing their stigmatic branches inwards towards the pollen of the few hermaphrodite florets, so as to effect geitonogamy. The pollen-grains are pale yellow in colour, ellipsoidal, with spinose tubercles, about 25 μ long and 19 μ broad.

VISITORS.—Herm. Müller observed the bee Sphecodes ephippius *L.*, skg.

449. Helichrysum Vaill.

Ray-florets female, filiform, uniseriate; disk-florets hermaphrodite, tubular.

1440. **H. arenarium** Moench (=Gnaphalium arenarium *L.*).—The citron-coloured involucral bracts make the heads of this species conspicuous.

According to Warnstorf (Verh. bot. Ver., Berlin, xxxiii, 1896), only the variety without filiform female ray-florets occurs at Neu-Ruppin; the variety with orange-red involucral bracts is not rare. The tip of each stylar branch possesses a bunch of papillose sweeping-hairs, below which the stigmatic papillae are situated on the inner surface. At first the style projects but little or not at all from the anther-cylinder, but later on the diverging stigmatic branches project between the anthers so as to ensure geitonogamy. The pollen-grains are golden-yellow in colour, rounded or ellipsoidal, spinose, as much as 31 μ long and 23 μ broad.

VISITORS.—Herm. Müller (Brandenburg) repeatedly observed the beetle Coccinella quattuordecimpunctata *L.*, resting on the heads ('Weit. Beob.,' III, p. 89).

1441. **H. bracteatum** Andr. (Knuth, 'Blütenbiol. Herbstbeob.,' 'Blütenbiol. Notizen.')—

VISITORS.—*The following were recorded by the observers, and for the localities stated.*—

Knuth (Kiel Botanic Garden), a true wasp (Vespa vulgaris *L.*), 2 hover-flies (Eristalis arbustorum *L.*, and Helophilus pendulus *L.*), 2 beetles (Coccinella quinquepunctata *L.*, and C. quattuordecimpunctata *L.*, especially the latter), and earwigs (Forficula, dvg. the florets). Schletterer (Tyrol), the parasitic humble-bee Psithyrus rupestris *F.*, and the carpenter-bee Xylocopa violacea *L.*

1442. **H. angustifolium** DC.—

VISITORS.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Eriades truncorum *L.*; 2. Eucera interrupta *Baer.*; 3. Halictus leucozonius *Schr.*; 4. H. quadricinctus *F.*; 5. H. scabiosae *Rossi*; 6. Megachile muraria *L.* (*b*) *Scoliidae*: 7. Scolia hirta *Schr.*; 8. S. insubrica *Scop.*

450. Artemisia L.

Varies from class **An** to class **Po**. As Kirchner mentions ('Beiträge,' p. 67), Delpino has shown that the group of Compositae constituted by him under the name of Artemisiaceae, is anemophilous ('Studi sopra un lignaggio anemofilo delle Composte, &c.,' Firenze, 1871). The florets have become inconspicuous; the heads are often pendulous; there is no nectar; the pollen is dry, and scattered without the agency of animals.

Delpino describes various degrees of anemophily: the initial stage is found in the genus Artemisia, and the adaptation is complete in the closely related genus Oligosporus *Cass.* as well as in the groups Iveae and Ambrosieae.

In the genus Artemisia (including Oligosporus) Delpino distinguishes the following stages.—Artemisia (*sens. strict.*) embraces species with heads containing hermaphrodite as well as female florets; the stigmatic branches of the former diverge in the usual way, and ultimately become recurved. Oligosporus is purely monoecious: in each head there are purely male florets along with female ones:

the ovaries of the former are vestigial, and the papillose stigmatic branches do not diverge.

Delpino divides the genus Artemisia (*sens. strict.*) into three sub-genera.—1. Absinthium *Tourn.* (A. Absinthium *L.*, and A. camphorata *Vill.*), representing early stages of anemophily, i. e. with dust-like pollen that scatters itself, but with the stigmas of the female florets still short, brightly coloured corollas to the hermaphrodite florets, and heads that are not always pendulous. 2. Evartemia *Delp.* With better marked adaptations to anemophily, i. e. prominent feathery stigmas in the female florets, inconspicuous brownish corollas, and ovoid or ventricose pendulous heads. 3. Seriphidium *Bess.* With further specialized adaptations to anemophily, especially heads containing a small number of hermaphrodite homogamous florets.

Kirchner rightly maintains that, between the normal Senecionidae and the species of Artemisia belonging to Delpino's sub-genus Absinthium, it would be more correct to introduce another group, iucluding those species of Artemisia (e. g. A. glacialis *L.*, A. Mutellina *Vill.*, and A. spicata *Wulf.*) which may more accurately be described as entomophilous than anemophilous. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes as follows the flower mechanism of A. Absinthum, A. vulgaris, and A. campestris.—The florets of the small heads are all tubular; the female ray-florets possess a corolla-tube that is somewhat wider below and narrows gradually above, passing into a 5-partite limb not sharply defined. The stylar branches are developed before the central hermaphrodite florets are mature. In A. vulgaris and A. campestris they are relatively long, devoid of apical thickenings and actual sweeping-hairs, but closely beset with stigmatic papillae. At a later stage they diverge and curve more or less outwards, so as to come into contact with the pollen produced by their own capitulum. The yellow or reddish hermaphrodite florets are bell-shaped above, and the corolla-lobes expand when the pollen is ripe, so that the five awl-shaped appendages on the upper part of the anther cylinder protrude. The two stigmatic branches lie close together, and are expanded above, forming a funnel-shaped apical depression covered all round with long papillose sweeping-hairs. They are still within the anther-cylinder, but have already brushed out the pollen. This lodges only for a short time between the appendages of the anthers, for owing to its small size and the absence of any means of adhesion it is soon carried away by the wind. The position of the head is also exceedingly favourable to anemophily. The stylar branches now project beyond the limb of the corolla, and curve outwards from one another. They turn their inner stigmatic surfaces upwards, and the appendages of the anther-cylinder retract themselves into the corolla. The pollen-grains are small, yellowish in colour, rounded or ellipsoidal, tuberculated, on an average 25 μ long and 18 μ broad.

1443. **A. glacialis** L.—Kirchner ('Beiträge,' pp. 67–8) says that at Zermatt the individual florets of this species are very small, but the inflorescences are by no means inconspicuous, for the corollas are of a golden-yellow colour. About 30–40 florets are aggregated into an erect head 4–6 mm. in diameter, and usually 5–7 of these are crowded together. The species is gynomonoecious, with protandrous hermaphrodite florets. In each head there are female ray-florets. Pollen is brushed out of the central hermaphrodite florets by the two apposed stylar branches, which are somewhat expanded above and covered with sweeping-hairs, while below they

are beset internally with stigmatic papillae. These branches are relatively broad and long, and ultimately bend outwards from one another till they become reflexed. The yellow pollen is not mealy and not readily dispersed, but clumps of it remain clinging to the top of the anther-cylinder. The florets are nectarless, and the annular nectary at the base of the style is absent.

1444. **A. borealis** Pall. (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlands-exped.,' pp. 64–5.)—This very variable species was several times collected by Drs. von Drygalski and Vanhöffen in Greenland. The colour of the involucral bracts and corolla-lobes of male florets is often purple, but may be golden-yellow or greenish-white. In many cases the heads are almost purely male or predominatingly female, and either protogynous or protandrous.

1445. **A. Mutellina** Vill.—This species, like A. glacialis, was investigated at Zermatt by Kirchner ('Beiträge,' p. 69). It, too, belongs to class **Po**, with transition to class **An.** The inflorescences are smaller, and their racemose arrangement also tends to make them less conspicuous. A head usually consists of 8–16 golden-yellow florets, of which the 5–8 marginal ones are female. Their stigmas mature before the pollen of the hermaphrodite florets of the same head is available, so that they are usually crossed by pollen from older heads, geitonogamously according to Kerner.

1446. **A. Absinthium** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 89–90.)—This species belongs to class **Po** with transition to class **An.** The numerous, almost spherical heads (about 4 mm. in diameter) are closely crowded on the many switch-like branches that are easily moved by the wind. The stem is more than a metre high. The plant is rendered tolerably conspicuous by the yellow colour of the tiny florets, of which about 50 are aggregated into a head. Each of them, including the ovary, is only 2 mm. long. The stylar branches of the central female florets possess a few sweeping-hairs at their tips, and when the pollen has been removed they roll up into two circular coils that project beyond the corolla, and present their stigmatic surfaces to alighting insects, by which they may be pollinated. Pollen-devouring insects are now and then attracted to the plant by sight, though it is only moderately conspicuous, and by its aromatic odour.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel), the hover-fly Syrphus ribesii *L.*, po-dvg. ('Bloemenbiol. Bijdragen'). Rössler (Wiesbaden), the moth Grapholitha pupillana *Cl.* Schletterer (Tyrol), the bee Andrena combinata *Chr.*

1447. **A. Dracunculus** L.—

VISITORS.—Borgstette (Nassau) observed a po-dvg. hover-fly (Melanostoma mellina *L.*).

1448. **A. maritima** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 90.)—This species possesses an aromatic odour. The short-stalked ovoid heads are easily moved by the wind.

1449. **A. vulgaris** L. (Knuth, loc. cit.)—The very small ovoid heads are 6 mm. long and 3 mm. broad. Each contains about 20 florets 4 mm. in length. MacLeod gives a figure (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 420).

1450. A. campestris L.—

Visitors.—Rössler records the following **Lepidoptera** for Wiesbaden, but makes no reference to the object of their visits.—

1. Conchylis dipoltella *Hb.*; 2. Crambus alpinellus *Hb.*; 3. Eurycreon turbidalis *Tr.*; 4. Grapholitha lactaena *Tr.*

451. Cotula L.

Heads golden-yellow in colour, solitary. Ray-florets female, barren, with inflated corolla-tube: disk-florets hermaphrodite, with 4-toothed limb to corolla.

1451. C. coronopifolia L. (Roth, Bot. Jahrb., Leipzig, v, 1884.)—Roth, at Lütjenburg (Holstein), repeatedly endeavoured to observe insects pollinating the florets, but never succeeded in doing so. The heads, though crowded together, are not at all conspicuous; besides which they are odourless, and appear to produce scarcely any nectar. Roth suggests that perhaps some suitable insect, absent from our area, may be found in California, which would account for the rapid spread of the species there, and its almost stationary condition in the far North of Europe. This idea does not appear to me to be supported by the facts, for nectar is secreted at no great depth, and therefore accessible to most of our flower-visiting insects. The case is one of insufficient observation.

452. Ammobium R. Br.

1452. A. alatum R. Br.—

Visitors.—I observed the beetle Coccinella quattuordecimpunctata *L.*, occasional, in the Kiel Botanic Garden.

453. Achillea L.

Gynomonoecious. Heads small. Ray-florets female, white (rarely rose-coloured), with rounded tongue, style devoid of sweeping-hairs. Disk-florets usually yellowish and hermaphrodite; style with diverging sweeping-hairs at the tip, and two bands of stigmatic papillae, separated by a median space, internally.

1453. A. Millefolium L. (Herm. Müller, 'Fertilisation,' pp. 325–7, 'Alpenblumen, p. 428, 'Weit. Beob.,' III, p. 84; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 90, 157–8, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 236; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 363, v, 1893, pp. 421–3; Loew, 'Blütenbiol. Floristik,' pp. 390, 395.)—In this species a large number of heads (often over 100) are arranged in a corymbose manner, thus giving a continuous flat surface. Not only is the plant thus rendered conspicuous, but a single visitor may pollinate numerous florets. Insects can pass from one head to another, using the contiguous ligulate ray-florets as bridges, without having to fly.

Hermann Müller states that a head contains about 20 disk-florets, with corolla-tubes hardly 2 mm. long, and expanding into nectar-containing bells about 1 mm. in length. The two stylar branches are closely apposed when the floret opens, and are situated in the lowest part of the anther-cylinder, through which they grow, pushing the pollen before them by means of the sweeping-hairs. They then diverge,

turning their stigmatic surfaces upwards, and protrude a little from the bell, while the empty anthers become somewhat retracted. The disk-florets are usually surrounded by 5 ray-florets with large corolla-limbs and no stamens; these increase the diameter of the head to 9–10 mm.

Failing insect-visits, automatic self-pollination is effected in the disk-florets by the fall of pollen from the sweeping-hairs on the outspread stigmatic papillae.

Gynodioecism is also said to occur occasionally.

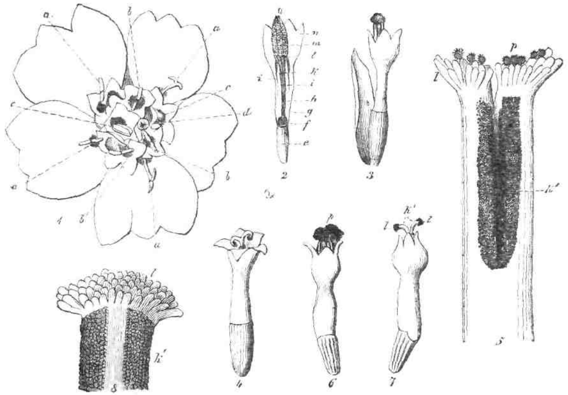


FIG. 199. *Achillea Millefolium*, *L.* (after Herm. Müller). (1) A single head, seen from above: *a*, stigmas of purely female ray-florets; *b*, do. of disk-florets in the second stage; *c*, anther-cylinder of disk-floret in the first stage; *d*, bud nearly ready to open. (2) Single disk-floret in the act of opening, seen in longitudinal section: *e*, ovary; *f*, nectary; *g*, style; *h*, corolla-tube; *i*, filaments; *k*, stylar branches; *l*, tip of the style, with sweeping-hairs; *m*, anther-cylinder; *n*, throat of corolla; *o*, valves closing the anther-cylinder. (3) Disk-floret (with bract) somewhat more advanced; pollen is issuing from the anther-cylinder. (4) Older disk-floret; the diverging stylar branches protrude, and the anther-cylinder is retracted into the corolla. (5) Tip of the style of a disk-floret in the first (male) stage: *k'*, stigmatic papillae; *l*, sweeping-hairs; *p*, pollen-grains.

Chrysanthemum Leucanthemum, *L.* (6) Disk-floret in the first (male) stage: *p*, pollen. (7) Do., in the second (female) stage. (8) Tip of a stylar branch, seen from within (× 60): *k'*, stigmatic papillae; *l*, sweeping-hairs.

VISITORS.—I observed the following in Schleswig-Holstein (S.-H.), and on the higher part of Helgoland (H.).—

A. Coleoptera. All po-dvg. (*a*) *Curculionidae*: 1. Apion marchicum *Hbst.* (S.-H.). (*b*) *Nitidulidae*: 2. Meligethes sp. (S.-H.). (*c*) *Telephoridae*: 3. Cantharis fulva *Scop.* (S.-H.). **B. Diptera.** (*a*) *Muscidae*: all skg.: 4. Anthomyia sp. (S.-H.); 5. Aricia incana *Wied.* ♀ (S.-H.); 6. Dolichopus plumipes *Scop.* (S.-H.); 7. Leucostoma aenescens *Zett.* (S.-H.); 8. Lucilia caesar *L.* (S.-H.); 9. Musca corvina *F.* (S.-H.); 10. Nemotelus uliginosus *L.* (S.-H.); 11. Oliviera lateralis *F.*, skg. (S.-H.); 12. Onesia sp. (S.-H.); 13. Pollenia sp. (S.-H.); 14. Sarcophaga carnaria *L.* (S.-H.); 15. S. striata *Fabr.* (S.-H.); 16. Scatophaga lutaria *F.* (S.-H.); 17. S. merdaria *F.* (S.-H.); 18. S. stercoraria *L.* (S.-H. and H.); 19. Spilogaster carbo-

nella *Zett.* (S.-H.). (*b*) *Syrphidae*: all skg. and po-dvg.: 20. Eristalis arbustorum *L.* (S.-H.); 21. E. pertinax *Scop.* (S.-H.); 22. E. tenax *L.* (S.-H.); 23. Helophilus pendulus *L.* (S.-H.); 24. Syritta pipiens *L.* (S.-H.). **C. Lepidoptera.** All skg. (*a*) *Rhopalocera*: 25. Epinephele janira *L.* (S.-H.); 26. Pieris sp. (S.-H.); 27. Polyommatus phlaeas *L.* (S.-H.). (*b*) *Sphingidae*: 28. Zygaena filipendulae *L.* (S.-H.). **D. Orthoptera.** 29. Forficula auricularia *L.*, gnawing the florets (H.).

Loew gives the following for Brandenburg (B.) and Mecklenburg (M.) ('Beiträge,' p. 39).—

A. Diptera. (*a*) *Conopidae*: 1. Zodion cinereum *F.* (M.). (*b*) *Stratiomyidae*: 2. Nemotelus uliginosus *L.* ♀ and ♂ (M.). (*c*) *Syrphidae*: 3. Eristalis aeneus *Scop.* (B.); 4. E. sepulcralis *L.* (B.). **B. Hymenoptera.** (*a*) *Apidae*: 5. Colletes fodiens *K.* ♂, po-cltg. (M.); 6. Prosopis dilatata *K.* ♂, skg. (M.). (*b*) *Ichneumonidae*: 7. Undetermined sp. (M.). (*c*) *Sphegidae*: 8. Oxybelus bellus *Dahlb.* (M.).

And in Silesia (op. cit., pp. 25–6).—

A. Diptera. (*a*) *Muscidae*: 1. Cistogaster globosa *F.*, skg.; 2. Gymnosoma rotundata *L.*, do.; 3. Ocyptera brassicaria *F.*, do. (*b*) *Syrphidae*: 4. Eristalis intricarius *L.*, skg.; 5. E. tenax *L.*, do. **B. Hymenoptera.** (*a*) *Apidae*: 6. Cilissa tricincta *K.* ♂, skg.; 7. Coelioxys octodentata *Lep.* ♂, do. (*b*) *Chrysididae*: 8. Hedychrum lucidulum *F.* (*c*) *Sphegidae*: 9. Cerceris nasuta *Dahlb.*, skg. **C. Lepidoptera.** 10. Polyommatus virgaureae *L.*

To these he adds (op. cit., p. 49).—**A. Diptera.** *Syrphidae*: 1. Chrysogaster coemeteriorum *L.* **B. Hymenoptera.** *Tenthredinidae*: 2. Tenthredo sp. Also (op. cit., p. 30).—**A. Coleoptera.** *Cerambycidae*: 1. Leptura testacea *L.*, nect-lkg. **B. Diptera.** (*a*) *Stratiomyidae*: 2. Odontomyia irridula *F.*, skg. (*b*) *Syrphidae*: 3. Syritta pipiens *L.*, skg.; 4. Volucella bombylans *L.*, do. **C. Lepidoptera.** *Rhopalocera*: all skg.: 5. Argynnis aglaja *L.*, skg.; 6. A. pandora *S.V.*; 7. Coenonympha arcania *L.*

Willis observed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Cercus rufilabris *Ltr.*, very common, po-dvg. (*b*) *Staphylinidae*: 2. Quedius boops *Grav.*, po-dvg. **B. Diptera.** (*a*) *Chironomidae*: 3. Cricolopus sp., po-dvg. (*b*) *Muscidae*: 4. Anthomyia radicum *L.*, freq., skg. and po-dvg.; 5. A. sp.; 6. Hydrellia griseola *Fall.*, po-dvg.; 7. Hyetodesia incana *W.*, skg.; 8. Lucilia sericata *Mg.*, skg. and po-dvg.; 9. Oliviera lateralis *F.*, skg.; 10. Phorbia floccosa *Mcq.*, po-dvg.; 11. Scatophaga stercoraria *L.*, do.; 12. Spilogaster communis *Dev.*, skg. (*c*) *Syrphidae*: 13. Eristalis pertinax *Scop.*, po-dvg.; 14. E. tenax *L.*, skg.; 15. Sphaerophoria scripta *L.*, freq., skg.; 16. Syritta pipiens *L.*, skg.; 17. Syrphus balteatus *Deg.*, do. **C. Hemiptera.** 18. Anthocoris sp., freq., skg.; 19. Calocaris bipunctatus *F.*, skg.; 20. C. fulvomaculatus *Deg.*, freq., skg. **D. Lepidoptera.** All skg. (*a*) *Microlepidoptera*: 21. Chorentis myllerana *F.*; 22. Simaëthis fabriciana *Steph.* (*b*) *Noctuidae*: 23. Hydroecia nictitans (*L.*) *Bkh.* (*c*) *Rhopalocera*: 24. Pieris napi *L.*; 25. P. rapae *L.*; 26. Polyommatus phlaeae *L.*

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Achillea Millefolium and A. Ptarmica in Westphalia, Thuringia, and Nassau.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia millefolii *F.* (Budd.); 2. A. nitidula *L.* (H. M., Thuringia; Budd.). (*b*) *Cerambycidae*: 3. Leptura livida *F.*, po-dvg. (H. M.); 4. L. testacea *L.*, do. (H. M.); 5. Strangalia bifasciata *Müll.* (H. M., Thuringia); 6. S. melanura *L.*, po-dvg. (H. M., Bavarian Oberpfalz). (*c*) *Chrysomelidae*: 7. Cryptocephalus sericeus *L.*, gnawing the florets (H. M.). (*d*) *Coccinellidae*: 8. Coccinella mutabilis *Scrib.*, freq., resting on the heads (H. M.);

9. C. septempunctata *L.*, do. (H. M.); 10. Exochomus auritus *Scrib.*, freq. (H. M.). (*e*) *Elateridae*: 11. Agriotes gallicus *Lac.*, po-dvg. (H. M., Thur.); 12. A. ustulatus *Schall.*, do. (H. M., Thuringia and the Oberpfalz). (*f*) *Mordellidae*: 13. Mordella fasciata *F.* (H. M.). (*g*) *Oedemeridae*: 14. Oedemera podagrariae *L.*, po-dvg. (H. M., Thuringia). (*h*) *Scarabaeidae*: 15. Cetonia aurata *L.*, gnawing the florets (H. M., Thuringia). (*i*) *Telephoridae*: 16. Telephorus melanurus *F.*, as 15 (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 17. Exoprosopa capucina *F.*, in large numbers (H. M.). (*b*) *Conopidae*: 18. Conops flavipes *L.*, freq., skg. (H. M.); 19. E. scutellatus *Mg.*, skg. (H. M., Oberpfalz and Fichtelgebirge): 20. Physocephala vittata *F.*, freq., skg. (H. M.). (*c*) *Empidae*: 21. Empis livida *L.*, freq. (H. M.). (*d*) *Muscidae*: 22. Aricia vagans *Fall.* (H. M.); 23. Echinomyia ferox *Pz.*, skg. (H. M., Oberpfalz); 24. E. tessellata *F.*, do. (H. M.); 25. Gonia capitata *Deg.*, do. (H. M.); 26. Gymnosoma rotundata *Pz.*, do. (H. M., Budd.); 27. Ocyptera cylindrica *F.*, do. (H. M.); 28. Phasia crassipennis *F.* (H. M., Thuringia; Budd.); 29. Scatophaga stercoraria *L.*, po-dvg. (Budd.); 30. Trypeta pantherina *Fall.* (Budd.); 31. Ulidia erythrophthalma *Mg.*, very numerous (H. M., Thuringia). (*e*) *Syrphidae*: 32. Chrysotoxum bicinctum *L.*, po-dvg. (H. M., Oberpfalz); 33. Eristalis arbustorum *L.*, freq., skg. and po-dvg. (H. M.); 34. E. horticola *Deg.*, po-dvg. (Budd.); 35. E. nemorum *L.*, freq., skg. and po-dvg. (H. M.); 36. E. sepulcralis *L.*, do. (H. M.); 37. E. tenax *L.*, do. (H. M.); 38. Eumerus sabulonum *Fall.* (H. M.); 39. Helophilus floreus *L.*, po-dvg. (H. M.); 40. Melithreptus scriptus *L.* (H. M.); 41. M. taeniatus *Mg.* (H. M.); 42. Paragus bicolor *L.*, po-dvg. (Budd.); 43. Syritta pipiens *L.*, freq., skg. and po-dvg. (H. M.); 44. Syrphus ribesii *L.* (H. M., Oberpfalz); 45. Volucella bombylans *L.* (H. M.); 46. V. pellucens *L.* (H. M., Almetral). (*f*) *Stratiomyidae*: 47. Odontomyia viridula *F.*, freq. (H. M.). (*g*) *Tabanidae*: 48. Tabanus rusticus *L.*, freq. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 49. Andrena albicans *Müll.* ♂, skg. (H. M.); 50. A. argentata *Sm.* ♂, do. (H. M.); 51. A. chrysosceles *K.* ♀ (H. M.); 52. A. denticulata *K.* ♂, skg. (H. M.); 53. A. dorsata *K.* ♀ and ♂, in large numbers, skg. and po-cltg. (H. M.); 54. A. fulvicrus *K.* ♀ and ♂, do. (H. M.); 55. A. fuscipes *K.* ♂ (H. M.); 56. A. lepida *Schenck* ♂, skg. (H. M.); 57. A. nana *K.* ♂, do. (H. M.); 58. A. nigripes *K.* ♀, do. (H. M.); 59. A. pilipes *F.* ♂, do. (H. M.); 60. A. schrankella *Nyl.* ♂ (Budd.); 61. Chelostoma nigricorne *Nyl.* ♂, skg. (H. M.); 62. Colletes daviesanus *K.* ♀ and ♂, very common, skg. and po-cltg. (H. M., Oberpfalz; Budd.); 63. C. fodiens *K.* ♀ and ♂, very common, po-cltg., po-dvg. and skg.; 64. Halictus cylindricus *F.* ♀ and ♂, po-cltg. and skg. (H. M.); 65. H. interruptus *Pz.* ♀, po-cltg. (H. M., Thuringia); 66. H. leucozonius *Schr.* ♀, do. (H. M.); 67. H. maculatus *Sm.*, do. (H. M.); 68. H. morio *F.* ♀ and ♂, po-cltg. and skg. (H. M., Budd.); 69. H. quadricinctus *F.* ♀ and ♂, do. (H. M., Budd.); 70. H. rubicundus *Chr.* ♂, skg. (H. M.); 71. H. smeathmanellus *K.* ♀, do. (Budd.); 72. H. villosulus *K.* ♀, skg. and po-cltg. (H. M., Budd.); 73. Heriades truncorum *L.* ♀ and ♂, do. (H. M.); 74. Nomada ruficornis *L.* ♀, skg. (H. M.); 75. N. zonata *Pz.* ♀, do. (H. M.); 76. Osmia leucomelaena *K.* ♀, po-cltg. (H. M.); 77. O. spinulosa *K.* ♀, do. (H. M.); 78. Prosopis pictipes *Nyl.* ♀ and ♂, skg. and seizing pollen with its mouth-parts (H. M.); 79. P. confusa *Nyl.* ♀ and ♂ (Budd.); 80. P. variegata *F.* ♀ and ♂, very numerous, as P. pictipes (H. M., Budd.); 81. Rhophites quinquespinosus *Spin.* ♂, freq., skg. (H. M., Oberpfalz); 82. Sphecodes gibbus *L.* (and a var.) ♀ and ♂, skg. (H. M., Budd.); 83. Stelis breviuscula *Nyl.* ♀ and ♂, do. (H. M.). (*b*) *Chrysididae*: 84. Hedychrum lucidulum *F.* ♀ and ♂, in large numbers (H. M.). (*c*) *Evaniidae*: 85. Foenus sp. (Budd.). (*d*) *Sphegidae*: 86. Ammophila sabulosa *L.* (H. M.); 87. Cerceris arenaria *L.*, not infrequent (H. M.); 88. C. labiata *F.*, freq. (H. M.); 89. C. variabilis *Schr.*, very common (H. M.); 90. Ceropales maculatus *F.*, in large numbers (H. M.); 91. Crabro alatus *Pz.* ♀ and ♂, freq. (H. M.); 92. C. subterraneus *F.* ♀ (H. M.); 93. C. vexillatus *Pz.* ♂ (Budd.); 94. Dinetus pictus *F.* (H. M.); 95. Lindenius albilabris *F.*, in large numbers (H. M.); 96. Oxybelus bellus *Dahlb.*, numerous (H. M.); 97. O. nigripes

Oliv. ♀ (H. M.); 98. O. trispinosus *F.*, freq. (H. M.); 99. O. uniglumis *L.*, do. (H. M.); 100. Philanthus triangulum *F.* ♀ and ♂, do. (H. M.); 101. Pompilus chalybeatus *Schjödte* ♀ (H. M.); 102. P. plumbeus *F.* ♀ and ♂ (H. M.); 103. P. rufipes *L.* ♀ and ♂ (H. M.); 104. P. trivalis *Dahlb.* ♂ (H. M.); 105. P. viaticus *L.* ♂ (H. M.). (*e*) *Tenthredinidae*: 106. Allantus nothus *Klg.*, freq. (H. M., Budd.); 107. A. scrophulariae *L.* (H. M.); 108. Athalia rosae *L.*, pairing on the heads (H. M., Budd.); 109. Several undetermined sp. of Tenthredo (H. M.). (*f*) *Vespidae*: 110. Odynerus parietum *L.* ♀ (H. M., Budd.); 111. O. sinuatus *F.* ♀ (H. M.); 112. O. spinipes *L.* ♀ (Budd.); 113. Pterocheilus phaleratus *Ltr.* ♀ (H. M.). **D. Lepidoptera.** (*a*) *Pyralidae*: 114. Botys purpuralis *L.*, skg. (H. M.). (*b*) *Rhopalocera*: 115. Coenonympha arcania *L.*, skg. (H. M., Thuringia); 116. Epinephile janira *L.*, do. (H. M.); 117. Hesperia lineola *O.*, do. (H. M., Oberpfalz); 118. H. sylvanus *Esp.*, do. (H. M.); 119. Lycaena aegon *Schn.* (H. M.); 120. L. icarus *Rott.*, skg. (H. M., Oberpfalz); 121. Melanargia galatea *L.* do. (Budd.); 122. Pieris napi *L.* (H. M.); 123. P. rapae *L.*, skg. (H. M.); 124. Polyommatus phlaeas *L.* (H. M.); 125. Coenonympha pamphilus *L.* (H. M.). (*c*) *Tineidae*: 126. Pleurota schlaegeriella *Zell.*, skg. (Budd.).

Herm. Müller also saw 4 flies, 2 Hymenoptera, and 24 Lepidoptera in the Alps.

The following were recorded by the observers, and for the localities stated.—

Lindman (Dovrefjeld), several Lepidoptera, a humble-bee, and a fly. Wüstnei (Alsen), the ruby-wasp Hedychrum nobile *Scop.* Verhoeff (Norderney).—**A. Diptera.** (*a*) *Bibionidae*: 1. Dilophus vulgaris *Mg.*, not infrequent. (*b*) *Muscidae*: 2. Aricia incana *Wiedem.*; 3. Calliphora erythrocephala *Mg.* ♀; 4. Cynomyia mortuorum *L.*, not infrequent; 5. Cyrtoneura simplex *Loew* ♂; 6. Lucilia latifrons *Schin.*, very common; 7. Scatophaga stercoraria *L.*; 8. Stomoxys calcitrans *L.* (*c*) *Syrphidae*: 9. Eristalis arbustorum *L.*, very common; 10. Platycheirus manicatus *Mg.* ♀; 11. Syrphus balteatus *Deg.*, occasional; 12. S. corollae *F.* **B. Hymenoptera.** (*a*) *Apidae*: 13. Prosopis communis *Nyl.*; 14. Sphecodes cirsii *Verh.* ♂, occasional. (*b*) *Vespidae*: 15. Odynerus parietum *L.*, occasional. Alfken (Juist).—**Diptera.** (*a*) *Muscidae*: 1. Lucilia caesar *L.*; 2. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 3. Eristalis arbustorum *L.*; 4. Syritta pipiens *L.* Schmiedeknecht (Thuringia), the bee Andrena flavipes *Pz.*, 2nd gen. Krieger (Leipzig).—**Hymenoptera.** (*a*) *Apidae*: 1. Andrena flavipes *Pz.*; 2. Halictus maculatus *Sm.*; 3. Nomada roberjeotiana *Pz.*; 4. N. solidaginis *Pz.*; 5. Prosopis communis *Nyl.*; 6. P. nigrita *F.* (*b*) *Chrysididae*: 7. Chrysis neglecta *Shuck.*; 8. Hedychrum nobile *Scop.* (*c*) *Sphegidae*: 9. Cerceris labiata *F.*; 10. C. quinquefasciata *Rossi.* (*d*) *Vespidae*: 11. Eumenes coarctatus *L.* Sickmann (Osnabrück), the parasitic fossorial wasp Ceropales maculatus *F.*, once. Friese (Mecklenburg), 2 bees (Colletes impunctatus *Nyl.* and Prosopis variegata *F.*); (Alsace), the bee Colletes daviesanus *K.*; (Thuringia), the fossorial wasp Dinetus guttatus *F.* Gerstäcker (Berlin), the fossorial wasp Oxybelus quattuordecemnotatus *Jur.* Alfken (Bremen).—**A. Diptera.** *Syrphidae*: 1. Eristalis anthophorinus *Zett.*, not infrequent. **B. Hymenoptera.** (*a*) *Apidae*: 2. Colletes daviesanus *K.* ♀ and ♂, rare; 3. C. marginatus *L.* ♀ and ♂, do.; 4. Eriades truncorum *L.* ♀, do.; 5. Megachile argentata *F.* ♂, do.; 6. Stelis breviuscula, not infrequent. (*b*) *Sphegidae*: 7. Crabro quadrimaculatus *Spin.*, rare. **C. Coleoptera.** (*a*) *Cerambycidae*: 8. Leptura livida *L.*; 9. Stenopterus rufus *L.* (*b*) *Silphidae*: 10. Necrophorus vespillo *L.* Rössler (Wiesbaden), the Tineid Adela tombacinella *H.-Sch.* Schenck (Nassau), 6 bees—1. Halictus albipes *F.*; 2. H. morio *F.*; 3. Nomada furva *Pz.*; 4. Prosopis bipunctata *F.*; 5. P. brevicornis *Nyl.*; 6. P. nigrita *F.* Schiner (Austria), 8 Muscids—1. Besseria melanura *Mg.*; 2. Gymnosoma nitens *Mg.*; 3. Lauxania cylindricornis *F.*; 4. Metopia argentata *Macq.*; 5. Miltogramma ruficornis *Mg.*; 6. Saltella scutellaris *Fall.*; 7. Tephritis flavipennis *Loew*; 8. Urophora stigma *Loew.* F. F. Kohl (Tyrol), the ruby-wasp Hedychrum regium *Fabr.* Heinsius (Holland), the hawk-moth Ino statices *L.*, and the butterfly Lycaena aegon *Schn.* ♂. MacLeod (Flanders),

6 Hymenoptera, 5 hover-flies, 7 other Diptera, 4 Lepidoptera, and 3 beetles (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 423); (Pyrenees), 2 Hymenoptera, 4 beetles, and 11 flies (op. cit., iii, 1891, p. 362). Smith (England), the bees Colletes daviesanus *K.* and C. marginatus *L.* Saunders (England), 4 bees — 1. Colletes picistigma *Thoms.*; 2. Prosopis cornuta *Sm.*; 3. P. dilatata *K.*; 4. P. masoni *Saund.* Scott-Elliot (Dumfriesshire), numerous Hymenoptera, flies, Lepidoptera, and beetles ('Flora of Dumfriesshire,' p. 95).

1454. **A. Ptarmica** L. (Herm. Müller, 'Fertilisation,' pp. 327–9; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 90, 158, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 236; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893.)—The heads of this species are larger than in A. Millefolium, but not so many of them are grouped together, and the two species are about equally conspicuous. Hermann Müller says that they occur in equal abundance, and flower simultaneously, in the same localities

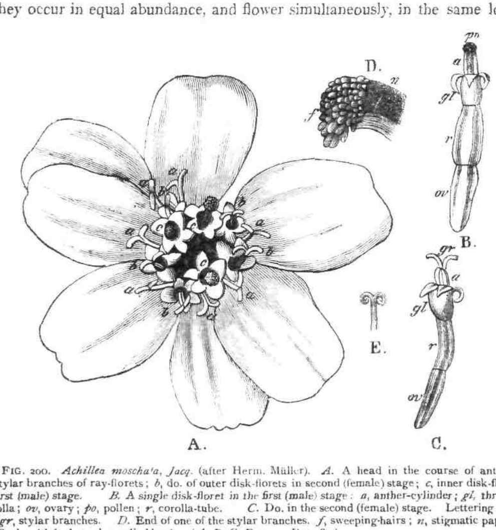


FIG. 200. *Achillea moschata, Jacq.* (after Herm. Müller). *A.* A head in the course of anthesis: *a*, stylar branches of ray-florets; *b*, do. of outer disk-florets in second (female) stage; *c*, inner disk-florets, in first (male) stage. *B.* A single disk-floret in the first (male) stage: *a*, anther-cylinder; *gl*, throat of corolla; *ov*, ovary; *po*, pollen; *r*, corolla-tube. *C.* Do. in the second (female) stage. Lettering as for *B*; *gr*, stylar branches. *D.* End of one of the stylar branches. *f*, sweeping-hairs; *n*, stigmatic papillae. *E.* Style with its branches rolled back. (*A, B, C, E*, × 7; *D*, × 80.)

in Westphalia, where they are visited with equal frequency by the same insects, especially by species of Prosopis, which are chiefly attracted by the odour of the plant. In other places, e. g. Schleswig-Holstein, A. Ptarmica is much less abundant than A. Millefolium, so that the insect visitors are also much less numerous.

Hermann Müller describes the heads of A. Ptarmica as containing 80–100 disk-florets scarcely 2½ mm. in length, which make up a surface 6–7 mm. in diameter. This is extended to 15–18 mm. by means of 8–12 ray-florets, of which the tongues are 4–6 mm. long, and about the same breadth.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands), a Lepidopterid, 3 Diptera, and a beetle; (Thuringia), the po-dvg. beetle Cetonia aurata *L.* MacLeod (Belgium), 2 flies (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 424). Loew (Berlin Botanic Garden), a Muscid (Echinomyia fera *L.*) and 2 Syrphids (Eristalis nemorum *L.*, and Syritta pipiens *L.*). Scott-Elliot (Dumfriesshire), a hover-fly and a Muscid ('Flora of Dumfriesshire,' p. 95). For the list given by Herm. Müller, see pp. 613–15.

1455. **A. moschata** Jacq. (Herm. Müller, 'Alpenblumen,' pp. 426–8.)—This species is gynomonoecious (in the Upper Engadine), with protandrous hermaphrodite florets. The diameter of the yellow disk is 3–5 mm., that of the entire head is 10–14 mm. Numerous heads are aggregated into a corymb. The 20–25 hermaphrodite disk-florets mature successively in centripetal order. Failing insect-visitors, automatic self-pollination easily takes place, partly by the fall of pollen from the papillose sweeping-hairs upon the expanded inner (stigmatic) surfaces of the stylar branches, partly by the rolling back of these until the stigmatic papillae touch the undivided part of the style. The plant is odorous.

Visitors.—Herm. Müller observed a beetle, 9 flies, 2 bees, and 10 Lepidoptera.

1456. **A. nana** L. (Herm. Müller, 'Alpenblumen,' p. 428.)—The flower mechanism agrees with that of A. moschata, but there are only 6–9 heads in the corymb, which is 12–20 mm. in diameter. There are about 20 disk-florets, and 7–10 ray-florets.

Visitors.—Herm. Müller observed 10 species of Diptera.

1457. **A. atrata** L. (Herm. Müller, 'Alpenblumen,' pp. 428–9.)—The flower mechanism of this species agrees with that of A. moschata. About 50 disk-florets and 9–12 ray-florets make up a head 12–18 mm. in diameter, and 3–8 heads are aggregated into a corymb.

Visitors.—Herm. Müller observed 5 beetles, 9 flies, a Hymenopterid, and 2 Lepidoptera.

1458. **A. macrophylla** L. (Herm. Müller, 'Alpenblumen,' pp. 429–30.)—This species is gynomonoecious, with protandrous hermaphrodite florets. Each head is 10 mm. in diameter, and consists of about 20 disk-florets, and usually 5 ray-florets: 6–12 heads are aggregated into a dense corymb 25–40 mm. in breadth. Automatic self-pollination is easily possible.

1459. **A. coronopifolia** Willd.—

Visitors.—Loew observed the fossorial wasp Dinetus pictus *F.* ♂ in the Berlin Botanic Garden.

1460. **A. dentifera** DC.—

Visitors.—Loew observed the hover-fly Eristalis arbustorum *L.* in the Berlin Botanic Garden.

1461. **A. filipendulina** Lam.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella quattuordecimpunctata *L.* **B. Diptera.** *Syrphidae*: 2. Syritta pipiens *L.* **C. Hemiptera.** 3. Calocoris sp.; 4. Corizus parumpunctatus *Schill.* **D. Hymenoptera.** *Vespidae*: 5. Eumenes coarctatus *L.*

1462. **A. grandifolia** Frivald.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp. (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*; 3. E. nemorum *L.*; 4. Helophilus floreus *L.*; 5. Syritta pipiens *L.* **B. Hymenoptera.** *Sphegidae*: 6. Eumenes coarctatus *L.* **C. Lepidoptera.** *Rhopalocera*: 7. Pieris brassicae *L.*, skg.

1463. **A. nobilis** L.—

VISITORS.—Loew observed 2 hover-flies (Eristalis arbustorum *L.*, and E. nemorum *L.*) and a bee (Sphecodes gibbus *L.* ♀, skg.) in the Berlin Botanic Garden.

1464. **A. tanacetifolia** All., var. **dentifera** DC.—

VISITORS.—Loew observed the hover-fly Syritta pipiens *L.* in the Berlin Botanic Garden.

454. Anthemis Mich.

Ray-florets white or yellow in colour, somewhat elongated. Heads larger than in Achillea, but structure of the style the same.

1465. **A. arvensis** L. (Herm. Müller, 'Fertilisation,' p. 329; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.' pp. 90, 158.)—Hermann Müller describes the heads of this species as being 21-7 mm. in diameter, of which 5-7 mm. are taken up by the yellow disk. The number of florets in the latter reaches several hundreds, while Ludwig states that there are usually 5, 8, or 13 ray-florets. The sweeping-hairs of the female florets are considerably shorter than those of the hermaphrodite ones. (*Cf.* Fig. 202, 8.)

Automatic self-pollination is always possible, as in Achillea Millefolium.

VISITORS.—Herm. Müller gives the following list.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *L.* (*b*) *Curculionidae*: 2. Bruchus sp. (*c*) *Elateridae*: 3. Athous niger *L.* **B. Diptera.** (*a*) *Muscidae*: 4. Echinomyia tessellata *F.*, po-dvg.; 5. Scatophaga merdaria *F.*, do.; 6. S. stercoraria *L.*, do. (*b*) *Stratiomyidae*: 7. Nemotelus pantherinus *L.*, extremely numerous. (*c*) *Syrphidae*: all po-dvg.: 8. Eristalis arbustorum *L.*; 9. E. nemorum *L.*; 10. E. sepulcralis *L.*; 11. E. tenax *L.* **C. Hymenoptera.** (*a*) *Apidae*: 12. Andrena fulvicrus *K.* ♀, skg. and po-dvg.; 13. A. minutula *K.* ♂; 14. A. nana *K.* ♀, skg.; 15. A. nigroaenea *K.* ♀, skg. and po-cltg.; 16. A. schrankella *Nyl.* ♀, do.; 17. Apis mellifica *L.* ☿, skg.; 18. Colletes daviesanus *K.* ♀ and ♂, freq., skg. and po-cltg.; 19. Halictus lucidulus *Schenck* ♀; 20. H. nitidiusculus *K.* ♀. (*b*) *Sphegidae*: 21. Cerceris variabilis *Schr.* ♂; 22. Crabro alatus *Pz.* ♀ and ♂; 23. C. cribrarius *L.* ♀. (*c*) *Tenthredinidae*: 24. Allantus nothus *Klg.*

The following were recorded by the observers, and for the localities stated.—

Knuth (Schleswig-Holstein), 2 bees and 5 flies; (Helgoland), the Muscid Lucilia caesar *L.* Wüstnei (Alsen), the bee Colletes daviesanus *K.* Schmiedeknecht (Thuringia), the bee Osmia montivaga *Mor.* Redtenbacher (Austria), the Cistelid Podonta nigritia *F.* Schletterer (Pola), 8 bees—1. Andrena convexiuscula *K.*, var. fuscata *K.*; 2. A. cyanescens *Nyl.*; 3. A. nana *K.*; 4. Eriades truncorum *L.*; 5. Halictus calceatus *Scop.*; 6. H. fasciatellus *Schenck*; 7. H. tetrazonius *Klug*; 8. Prosopis hyalinata *Smith*, var. corvina *Först.* Kohl (Tyrol), the very common sphegid Crabro cribrarius *L.*

1466. A. tinctoria L. (Herm. Müller, 'Fertilisation,' p. 329, 'Weit. Beob.,' III, pp. 86–8; Knuth, 'Bloemenbiol. Bijdragen.')—The diameter of the golden yellow disk is 12–18 mm. in this species. Hermann Müller describes it as consisting of from 300 to over 500 tubular hermaphrodite florets, surrounded by 30–35 female ray-florets, which are usually of the same colour. The entire head presents a circular surface 25–40 mm. across. The ray-florets open first: their stylar branches diverge and roll back to some extent. The disk-flowers next mature in centripetal order, in successive zones: their mechanism agrees with that of the disk-florets of Achillea Millefolium. As the corolla-tubes of the disk-florets are only 2 mm. in length, and the bells (into which the nectar ascends) are only 1 mm. long, the nectar is accessible even to insects with the shortest form of proboscis, provided this is of suitable thickness.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (Budd.). (*b*) *Cerambycidae*: 2. Strangalia bifasciata *Müll.* ♀ and ♂, po-dvg. (H. M., Thuringia). (*c*) *Chrysomelidae*: 3. Cryptocephalus sericeus *L.*, gnawing the anthers (H. M., Thuringia). (*d*) *Elateridae*: 4. Agriotes gallicus *Lac.* (H. M.). (*e*) *Mordellidae*: 5. Mordella aculeata *L.* (H. M.); 6. M. fasciata *F.* (H. M.). (*f*) *Oedemeridae*: 7. Oedemera flavescens *L.*, po-dvg. (H. M., Thuringia). **B. Diptera.** (*a*) *Bombyliidae*: 8. Exoprosopa capucina *F.* (Budd.). (*b*) *Conopidae*: 9. Myopa sp., skg. (H. M.). (*c*) *Muscidae*: 10. Anthomyia sp., po-dvg. (Budd.); 11. Aricia sp., po-dvg. (H. M., Thuringia); 12. Gymnosoma rotundata *L.* (H. M.); 13. Ocyptera brassicariae *F.*, skg. (H. M., Thuringia); 14. Ulidia erythrophthalma *Mg.*, very common (H. M., Thuringia). (*d*) *Syrphidae*: 15. Eristalis arbustorum *L.*, po-dvg. (H. M.); 16. Helophilus floreus *L.*, po-dvg. (H. M., Thuringia); 17. Melithreptus taeniatus *Mg.*, po-dvg. (H. M.); 18. Syritta pipiens *L.*, skg. and po-dvg. (H. M., Budd.). **C. Hemiptera.** 19. Calocoris chenopodii *Fall.*, skg. (H. M., Thuringia). **D. Hymenoptera.** (*a*) *Apidae*: 20. Colletes daviesanus *K.* ♀ skg. and po-cltg. (H. M., Thuringia), ♂ skg. (Budd.); 21. C. marginatus *L.* ♂, skg. (H. M.); 22. Halictus maculatus *Sm.* ♂ skg., ♀ po-cltg. (H. M., Budd.); 23. Heriades truncorum *L.* ♀, po-cltg. (H. M.); 24. Osmia spinulosa *K.* ♂, skg. (Budd.); 25. Prosopis propinqua *Nyl.* ♂, skg. (Budd.); 26. Rhophites quinquespinosus *Spin.* ♂, skg. (Budd.). (*b*) *Ichneumonidae*: 27. Several (H. M.). (*c*) *Tenthredinidae*: 28. Tarpa cephalotes *F.*, very common (H. M., Thuringia). (*d*) *Vespidae*: 29. Vespa rufa *L.* ☿, settling but flying off again at once (H. M., Thuringia). **E. Lepidoptera.** (*a*) *Rhopalocera*: 30. Epinephele janira *L.*, skg. (H. M., Thuringia); 31. Lycaena corydon *Scop.*, skg. (H. M., Thuringia); 32. Melanargia galatea *L.*, skg. (H. M., Thuringia); 33. Thecla ilicis *Esp.*, skg. (H. M., Thuringia; Budd.). (*b*) *Sphingidae*: 34. Zygaena achilleae *Esp.*, skg. (H. M., Thuringia). (*c*) *Tineidae*: 35. Nemotois dumeriliellus *Dup.*, skg. (Budd.).

The following were recorded by the observers, and for the localities stated.—

Knuth (on cultivated plants), some skg. and po-cltg. bees (Apis, and Halictus cylindricus *F.*), po-dvg. hover-flies (Eristalis arbustorum *L.*, E. tenax *L.*, E. nemorum *L.*, and Helophilus pendulus *L.*), and skg. Muscids (Lucilia caesar *L.*, L. cornicina *F.*, and Scatophaga stercoraria *L.*). Delpino the Bombyliid Lometia beelzebub *F.* ('Ult. oss.,' Soc. ital. sc. nat., Milano, xvii). Loew (Berlin Botanic Garden).—**A. Coleoptera.** *Coccinellidae*: 1. Coccinella impustulata *L.*; 2. C. quattuordecimpunctata *L.* **B. Diptera.** (*a*) *Muscidae*: 3. Anthomyia sp. (*b*) *Syrphidae*: 4. Eristalis nemorum *L.*; 5. Helophilus floreus *L.*; 6. Syritta pipiens *L.*; 7. Syrphus ribesii *L.* **C. Lepidoptera.** *Rhopalocera*: 8. Pieris brassicae *L.*, skg.

1467. A. rigescens Willd.—

Visitors.—Loew observed a Muscid (Anthomyia sp.) and 3 Syrphids (1. Eristalis tenax *L.*; 2. Melanostoma mellina *L.*; 3. Syritta pipiens *L.*) in the Berlin Botanic Garden.

1468. A. Cotula L.—Ludwig states that the white ray-florets are neuter and usually 8 or 13 in number.

455. Matricaria L.

Ray-florets ligulate, white in colour, sometimes wanting; disk-florets hermaphrodite, yellow. Structure of style as in Achillea (*cf.* Fig. 202, 10).

1469. M. Chamomilla L. (Ogle, Pop. Sci. Rev., London, ix, 1870, pp. 160–4; Herm. Müller, 'Fertilisation,' p. 332, 'Weit. Beob.,' III, p. 86; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 91, 158; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893.)—The diameter of the entire head in this species is 18–24 mm., that of the disk 6–8 mm. Hermann Müller points out that as the florets mature in centripetal order, the common receptacle rises up into a cylinder terminated by a blunt cone. The florets which are over cover the cylinder, and the closed ones the cone, while the region actually in flower comes between the two. The last is naturally the part first touched by alighting insects, so that visitors constantly settle on the best place for obtaining booty, and for effecting pollination. In other respects the flower mechanism agrees with that of Anthemis arvensis.

Visitors.—These are more especially flies, while the strong odour of the heads is disagreeable to bees, with the exception of species of Prosopis.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *L.*, not infrequent (H. M.); 2. Strangalia attenuata *L.*, do. (H. M.). (*b*) *Nitidulidae*: 3. Meligethes, freq. (H. M.). **B. Diptera.** (*a*) *Empidae*: 4. Empis livida *L.*, skg. (H. M.). (*b*) *Muscidae*: 5. Lucilia cornicina *F.* (H. M.); 6. Pollenia vespillo *F.*, po-dvg. (H. M.); 7. Sarcophaga carnaria *L.*, freq., po-dvg. (H. M.); 8. S. haemorrhoa *Mg.*, po-dvg. (H. M.); 9. Spilogaster nigrita *Fall.* (H. M.). (*c*) *Stratiomyidae*: 10. Nemotelus pantherinus *L.*, very common, skg. (H. M.). (*d*) *Syrphidae*: 11. Eristalis arbustorum *L.*, very common, po-dvg. (H. M.); 12. E. nemorum *L.*, do. (H. M.); 13. E. sepulcralis *L.*, do. (H. M.); 14. Syritta pipiens *L.*, do. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 15. Colletes daviesanus *K.* ♂, in large numbers, skg. (Budd.); 16. Halictus nitidus *Schenck* ♂, skg. (Budd.); 17. Prosopis signata *Pz.* ♀ and ♂, freq., alternately settling and flying away (H. M., Budd.); 18. Sphecodes gibbus *L.* ♀ and ♂ (H. M.). (*b*) *Sphegidae*: 19. Oxybelus uniglumis *L.*, freq. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands), Apis, 9 flies, a Lepidopterid, and a beetle. Schletterer (Pola), the dasygastrid bee Eriades truncorum *L.* MacLeod (Flanders), a humble-bee, 2 Lepidoptera, and 7 beetles (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 424). Saunders (England), the two bees Colletes daviesanus *K.* and C. picistigma *Thoms.* Krieger (Leipzig), the very common bee Colletes daviesanus *K.*

1470. M. inodora L. (=Chrysanthemum inodorum *L.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 91, 158; Herm. Müller, 'Fertilisation,' p. 331, 'Weit. Beob.,' III, p. 86.)—The flower mechanism of this species essentially resembles that of Anthemis arvensis. Ludwig states that the almost odourless heads usually contain 13 or 21 ray-florets.

According to Kerner, the common receptacle is at first only slightly curved, but subsequently rises up so as to bring the stigmas of the outer tubular florets into the line of fall of pollen from the inner ones, so that geitonogamy takes place.

VISITORS.—Willis observed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Curculionidae*: 1. Anthonomus rubi *Herbst.*, freq. **B. Diptera.** (*a*) *Bibionidae*: 2. Scatopse brevicornis *Mg.*, freq., skg. (*b*) *Muscidae*: 3. Anthomyia radicum *L.*, very common, skg. and po-dvg.; 4. A. sp., po-dvg.; 5. Hydrellia griseola *Fall.*, skg. and po-dvg.; 6. Oscinis frit *L.*, freq., po-dvg.; 7. Drosophila graminum *Fall.*, freq., skg.; 8. Spilogaster communis *Dsv.*, skg.; 9. Themira minor *Hal.*, freq., skg. (*c*) *Mycetophilidae*: 10. Sciara sp., freq., skg. (*d*) *Syrphidae*: 11. Ascia podagrica *F.*, freq., skg.; 12. Eristalis pertinax *Scop.*, skg.; 13. E. tenax *L.*, do.: 14. Sphaerophoria scripta *L.*, do. **C. Hemiptera.** 15. Calocoris bipunctatus *F.*, freq.; 16. C. fulvomaculatus *Deg.*, do. **D. Hymenoptera.** (*a*) *Apidae*: all skg.: 17. Bombus lapidarius *L.*; 18. Halictus cylindricus *F.*; 19. H. rubicundus *Chr.*; 20. Prosopis brevicornis *Nyl.*; 21. Sphecodes affinis *Hag.*, freq. (*b*) *Vespidae*: 22. Odynerus pictus *Curt.*, freq., skg. **E. Lepidoptera.** All skg.: (*a*) *Microlepidoptera*: 23. Choreutis myllerana *F.*; 24. Simaëthis fabricana *Steph.* (*b*) *Rhopalocera*: 25. Polyommatus phlaeas *L.*, freq.

The following were recorded by the observers, and for the localities stated.—

Herm. Müller, a Chrysidid (Hedychrum lucidulum *F.* ♂) and a Muscid (Ulidia erythrophthalma *Mg.*). Knuth (Schleswig-Holstein).—**A. Diptera.** (*a*) *Dolichopodidae*: 1. Gymnopternus nobilitatus *L.* (*b*) *Muscidae*: all skg.: 2. Lucilia caesar *L.*; 3. L. cornicina *F.*; 4. Pollenia rudis *F.*; 5. Scatophaga merdaria *F.*; 6. small Muscids. (*b*) *Syrphidae*: all skg. and po-dvg.; 7. Eristalis arbustorum *L.*; 8. E. sp.; 9. E. tenax *L.* **B. Hymenoptera.** *Apidae*: 10. Colletes daviesanus *F.*, skg. Also (Helgoland), 4 Muscids, all skg. (1. Coelopa frigida *Fall.*; 2. Fucellia fucorum *Fall.*; 3. Lucilia caesar *L.*; 4. Olivieria lateralis *F.*) (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 40). Scott-Elliot (Dumfriesshire), numerous bees, flies, and Lepidoptera ('Flora of Dumfriesshire,' p. 94).

I investigated an interesting variety that occurs on the sea-shore at Kiel, M. maritima *L.* (as a species) (=Chrysanthemum maritimum *Pers.*). It is very conspicuous owing to the numerous large heads that are borne on the diffusely branched ascending stem. The plant exhales a faint odour of chamomile (intensified by rubbing) which leads one to suppose that flies are the pollinating agents. The white tongues of the 20–30 female ray-florets are (as in the type form) rather more than 1 cm. long, and about 4 mm. broad at the end. These florets surround several hundred tubular yellow disk-florets, presenting a surface over 1 cm. broad, so that the total diameter of the head is about $3\frac{1}{2}$ cm. The corolla of the disk-florets is about 2 mm. in length, including a bell (scarcely 1 mm. long) containing a little nectar. It is white in colour with yellow teeth.

The small florets are male during the first stage of anthesis: pollen is then pressed out of the tip of the anther-cylinder by upgrowth of the apposed stylar branches, and covers the surface of the floret. In the second (female) stage the stylar branches diverge so as to place their receptive inner surfaces in the position previously occupied by the pollen. It follows that insects creeping about on the surface of the head touch either the pollen or the stigmatic papillae, and effect the crossing of a large number of florets at one time. Should insect-visits fail,

the stylar branches gradually bend round till their stigmatic surfaces touch any pollen that may remain, and are thus automatically self-pollinated.

The florets develop in centripetal order (as in all Compositae), so that in the disk of a fully mature head they may be observed in the following stages, beginning at the outside,—faded, female stage, male stage, not yet open. As flowering progresses inwards, the at first sharply arched common receptacle swells up and becomes globular, so that florets which have yet to shed their pollen or are in the act of doing so are at a considerably higher level than those that have faded. It follows that alighting insects settle only on the former, and they avoid the faded florets situated on the sloping surface below. The arrangement is favourable to geitonogamy, as in the type form.

VISITORS.—I observed the hover-fly Eristalis arbustorum *L.*, and the Muscid Scatophaga merdaria *F.*, both skg.

1471. M. discoidea DC. (=Matricaria suaveolens *Buch.*, and Chrysanthemum suaveolens *Aschers.*).—In this species there are no ray-florets. The mechanism of the yellow disk-florets appears to be the same as in the last two species. Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896) describes it as follows.—Many very small hermaphrodite tubular florets about ½ mm. long are aggregated into an almost spherical yellowish-green head. They turn green after the pollen is matured, and become larger, so that the head increases considerably in size. The pollen is not raised above the corollas by the stylar branches, but lies between their lobes, which protect it from being carried away. Owing to the smallness of the flowers, geitonogamy inevitably results from the divergence of the stylar branches. The pollen-grains are yellow in colour, polyhedral, with spinose tubercles, about 25 μ in diameter.

VISITORS.—I observed the hover-fly Syritta pipiens *L.*, skg. and po-dvg., and the Muscid Scatophaga stercoraria *L.*, skg.

456. Tanacetum Tourn.

Ray-florets are wanting in some species, when present ligulate, and white in colour. Otherwise like Matricaria.

1472. T. vulgare L. (=Chrysanthemum Tanacetum *Vis.*). (Herm. Müller, 'Fertilisation,' pp. 232–3; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 91.)—The heads of this species are in one plane, as in Achillea, conferring the advantage that insect visitors can creep over the whole surface without having to use their wings, and a very large number of florets can be pollinated at the same time. The crowding together of numerous heads, though these are small and rayless, makes the plant so conspicuous that it is very easily seen, and therefore visited by a large number of insects.

Hermann Müller states that each head contains several hundred yellow florets. The bell of the corolla is only 1 mm. deep. The style has the same structure as in Achillea: it bears a capitate bunch of diverging sweeping-hairs at the tip of its branches, by which pollen is swept out of the anther-cylinder during the first stage of anthesis. In the second stage the stylar branches, which are beset internally with

stigmatic papillae, diverge in such a way as to stand at the same level as that previously occupied by the pollen masses.

Visitors.—Herm. Müller gives the following list.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella bipunctata *L.*; 2. C. quinquepunctata *L.* **B. Diptera.** (*a*) *Muscidae*: 3. Sarcophaga carnaria *L.* (*b*) *Stratiomyidae*: 4. Odontomyia viridula *F.*, freq. (*c*) *Syrphidae*: 5. Eristalis arbustorum *L.*, freq., po-dvg.; 6. E. nemorum *L.*, do.; 7. Melithreptus taeniatus *Mg.*, po-dvg.; 8. Syritta pipiens *L.*, very numerous, skg. and po-dvg.; 9. Syrphus ribesii *L.*, freq., po-dvg. **C. Hemiptera.** 10. Several sp. of bugs. **D. Hymenoptera.** (*a*) *Apidae*: 11. Andrena denticulata *K.* ♀, po-cltg.; 12. A. fulvicrus *K.* ♂, skg.; 13. Apis mellifica *L.* ☿, do.; 14. Colletes daviesanus *K.* ♂ and ♀, extraordinarily freq., skg. and po-cltg.; 15. C. fodiens *K.* ♂ and ♀, very common, skg. and po-cltg.; 16. Halictus maculatus *Sm.* ♂ and ♀, do.; 17. Sphecodes gibbus *L.* ♂ and ♀, different varieties (including ephippius *L.*), skg., and dusting itself with pollen. (*b*) *Sphegidae*: 18. Crabro sp.; 19. Dinetus pictus *F.* ♀ and ♂, in large numbers; 20. Mellinus arvensis *L.* (*c*) *Vespidae*: 21. Odynerus parietum *L.* ♂. **E. Lepidoptera.** (*a*) *Pyralidae*: 22. Botys purpuralis *L.*, skg. (*b*) *Noctuidae*: 23. Hadena didyma *Esp.* ♂, skg. (*c*) *Rhopalocera*: 24. Polyommatus dorilis *Hfn.*, skg.; 25. P. phlaeas *L.*, skg.; 26. Vanessa atalanta *L.*, skg. **F. Neuroptera.** 27. Panorpa communis *L.*, freq.

The following were recorded by the observers, and for the localities stated.—

Knuth, Apis, 2 humble-bees, a short-tongued bee, a Tenthredinid, 3 Lepidoptera, 5 hover-flies, 6 Muscidae, and a beetle ('Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 158–9). Wüstnei (Alsen), 4 bees (1. Colletes daviesanus *K.*; 2. Halictus albipes *Fbr.*; 3. H. morio *Fbr.*; 4. H. nitidiusculus *K.*). Friese (Mecklenburg), 5 bees (1. Colletes daviesanus *K.*, very common; 2. C. fodiens *K.*, freq.; 3. C. marginatus *Sm.*, rare; 4. Epeolus productus *Ths.*, not infrequent; 5. E. variegatus *L.*): also (Thuringia) the bee Colletes daviesanus *K.* Alfken (Juist), a Muscid (Lucilia caesar *L.*), a Capsid (Calocoris norvegicus *Gmel.*, very common, skg.), and a bee (Colletes daviesanus *K.* ♀, occasional. Sickmann (Osnabrück), 3 Sphegids (1. Ceropales maculatus *F.*, occasional; 2. Dioretus pictus *F.*, freq.; 3. Mellinus sabulosus *F.*, freq. Alfken (Bremen).—**A. Diptera.** (*a*) *Muscidae*: 1. Gymnosoma rotundata *L.*, rare. (*b*) *Syrphidae*: 2. Eristalis anthophorinus *Zett.*, very rare; 3. Melanostoma mellina *L.*, freq. **B. Hymenoptera.** (*a*) *Apidae*: 4. Bombus derhamellus *K.* ☿; 5. B. muscorum *F.* ☿; 6. B. terrester *L.* ♂, skg.; 7. Colletes daviesanus *K.* ♀ very common, skg. and po-cltg., ♂ very common, skg. (this is the most frequent visitor among the bees); 8. C. fodiens *K.*, freq., ♀ skg. and po-cltg., ♂ skg.; 9. C. picistigma *Ths.*, rare, ♀ skg. and po-cltg., ♂ skg.; 10. Epeolus variegatus *L.* ♀ and ♂, freq., skg.; 11. Eriades nigricornis *Nyl.* ♀, rare; 12. E. truncorum *L.* ♀ and ♂, freq.; 13. Halictus rubicundus *Chr.* ♀, rare; 14. Melitta leporina *Pz.* ♂; 15. Psithyrus barbutellus *K.* ♀; 16. Stelis breviuscula *Nyl.* ♀ and ♂, freq. (*b*) *Sphegidae*: 17. Ammophila affinis *K.* ♀, not infrequent, skg.; 18. Diodontus tristis *v. d. L.* ♀. (*c*) *Tenthredinidae*: 19. Athalia glabricollis *Ths.*; 20. A. spinarum *F.*; 21. Dolerus pratensis *Fall.* Schenck (Nassau), the following bees—1. Colletes fodiens *K.*; 2. Halictus minutulus *Schenck*; 3. H. nitidiusculus *K.*; 4. H. pauxillus *Schenck* ♂; 5. Nomada rhenana *Mor.*; 6. N. ruficornis *L.*; 7. Prosopis bipunctata *F.*; 8. P. nigrita *F.* MacLeod (Flanders), Apis, 4 short-tongued bees, 4 hover-flies, 6 Muscids, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 426–7): also a Muscid, a Vespid, and a beetle (op. cit., vi, 1894, p. 374). Schneider (on imported plants in Arctic Norway), the humble-bee Bombus terrester *L.* ♂ and ♀, by the hundred (1890), also B. lapponicus *L.* and B. scrimshiranus *K.* (Tromsø Mus. Aarsh., 1894). Smith (England), 3 bees (1. Colletes daviesanus *K.*; 2. C. fodiens *K.*; 3. Epeolus variegatus *L.*). Loew (Berlin Botanic Garden), the Muscid Tephritis elongatula *Lw.*, and undetermined hemipterous larvae.

1473. **T. corymbosum** Sch. Bip. (= Chrysanthemum corymbosum *L.*, and Pyrethrum corymbosum *Scop.*).—Kerner made comparative cultivations of this species in the Vienna Botanic Garden and on the Blaser in the Tyrol, and observed that the lowland specimens developed larger heads (26 mm. in diameter), and larger ray-florets (tongues 8 mm. long and 4 mm. broad) than the highland ones, the heads of which were only 20 mm. in diameter with ray-florets 7 mm. long.

VISITORS.—Herm. Müller observed the following in Thuringia.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (*b*) *Cerambycidae*: 2. Strangalia bifasciata *Müll.* ♀ and ♂, freq.; 3. S. melanura *L.*, both po-dvg. (*c*) *Curculionidae*: 4. Spermophagus cardui *Stev.* (*d*) *Mordellidae*: 5. Mordella aculeata *L.* (*e*) *Oedemeridae*: 6. Oedemera marginata *F.*; 7. O. virescens *L.*, po-dvg. (*f*) *Telephoridae*: 8. Danacea pallipes *Pz.*; 9. Dasytes flavipes *F.* **B. Diptera.** (*a*) *Bombyliidae*: 10. Anthrax morio *L.* (*b*) *Empidae*: 11. Empis livida *L.*, freq., skg. (*c*) *Muscidae*: 12. Aricia sp.; 13. Ulidia erythrophthalma *Mg.*, in very large numbers. (*d*) *Stratiomyidae*: 14. Nemotelus pantherinus *L.*, skg. **C. Hemiptera.** 15. Capsus sp., skg.; 16. Phytocoris ulmi *L.*, skg. **D. Hymenoptera.** (*a*) *Apidae*: 17. Halictus maculatus *Sm.* ♀, freq., skg. and po-cltg.; 18. Prosopis confusa *Nyl.* ♂; 19. P. variegata *F.* ♀ and ♂, skg. and po-dvg., also *in copulâ* on the heads. (*b*) *Sphegidae*: 20. Cerceris variabilis *Schr.* ♀. (*c*) *Chrysididae*: 21. Hedychrum lucidulum *F.* ♂. (*d*) *Tenthredinidae*: 22. Tarpa cephalotes *F.*, skg. (?). **E. Lepidoptera.** (*a*) *Rhopalocera*: 23. Melitaea athalia *Esp.*, skg.; 24. Thecla spini *S. V.*, do. (*b*) *Sphingidae*: 25. Zygaena sp., do.

Loew noticed the Sphegid Dinetus pictus *F.* ♂ in the Berlin Botanic Garden.

1474. **T. Parthenium** Sch. Bip. (= Chrysanthemum Parthenium *Bernh.*, Matricaria Parthenia *L.*, and Pyrethrum Parthenium *Sm.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 93, 159.)—In this species the style of the white female ray-florets has no apical sweeping-hairs, but the yellow disk-florets possess them just like Matricaria Chamomilla, though the stylar branches do not diverge so much in the second stage of anthesis (*cf.* Fig. 202, 9). As Kirchner remarks ('Flora v. Stuttgart,' p. 711), they do not project at all from the corolla after the anther-cylinder has become retracted.

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (H. M.) and Buddeberg (Budd.), (Herm. Müller, 'Fertilisation,' p. 331, 'Weit. Beob.,' III, p. 96) the bee Halictus smeathmanellus *K.* ♀, skg. (H. M., Budd.), an Evaniid (Foenus sp.), skg. (H. M., Budd.), and the Sphingid Sesia tipuliformis *Cl.*, skg. (H. M.). Schletterer (Pola), 3 bees (1. Halictus levigatus *K.* ♀; 2. H. patellatus *Mor.*; 3. Andrena carbonaria *L.*).

1475. **T. alpinum** Sch. Bip. (= Chrysanthemum alpinum *L.*). (Herm. Müller, 'Alpenblumen,' pp. 430–2.)—This species is gynomonoecious with protandrous hermaphrodite florets. The yellow disk-florets greatly exceed 100 in number, and cover a circular area 10 mm. in diameter, which is extended by the white ray-florets (about 30 in number) to 30–4 mm. The florets develop in centripetal order. The possibility of self-pollination is ensured.

VISITORS.—Herm. Müller observed 3 beetles, 35 flies, 4 Hymenoptera, and 4 Lepidoptera.

Loew saw a Muscid (Anthomyia sp.) on the Piz Umbrail ('Blütenbiol. Floristik.' p. 397).

1476. T. atratum Sch. Bip. (=Chrysanthemum atratum *Jacq.*, and C. coronopifolium *Vill.*). (Herm. Müller, 'Alpenblumen,' p. 432.)—

The flower mechanism of this species agrees completely with that of the last one.

VISITORS.—Herm. Müller observed 7 flies.

1477. T. macrophyllum Sch. Bip. (=Chrysanthemum macrophyllum *Waldst. et Kit.*, and Pyrethrum macrophyllum *Willd.*).—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus scrophulariae *L.* (*b*) *Scarabaeidae*: 2. Cetonia aurata *L.*, freq. **B. Diptera.** *Muscidae*: 3. Lucilia caesar *L.* **C. Hymenoptera.** (*a*) *Apidae*: 4. Apis mellifica *L.* ☿, skg. and po-cltg.; 5. Prosopis communis *Nyl.* ♀, skg. (*b*) *Vespidae*: 6. Odynerus parietum *L.*

1478. T. parthenifolium Sch. Bip., var. *pulverulentum* (=Chrysanthemum praealtum *Vent.* and Pyrethrum parthenifolium *Willd.*).—

VISITORS.—Loew observed a Muscid (Ocyptera brassicaria *F.*), a Syrphid (Syritta pipiens *L.*), and a bug (Heriades truncorum *L.* ♀) in the Berlin Botanic Garden.

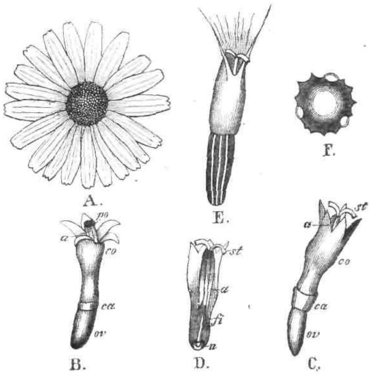


FIG. 201. *Tanacetum alpinum*, *Sch. Bip.* (after Herm. Müller). *A.* A head (natural size). *B.* Disk-floret in the first (male) stage (× 7). *C.* Do. in the second (female) stage (× 7). *D.* Do. in section; the ovary omitted (× 7). *E.* Ray-floret (× 7). *F.* Pollen-grain. *a*, anther-cylinder; *ca*, calyx; *co*, corolla; *fi*, filaments; *n*, nectary; *ov*, ovary; *po*, pollen; *st*, stylar branches.

1479. T. Meyerianum Sch. Bip. (=Pyrethrum tanacetoides *DC.*).—

VISITORS.—Loew saw a beetle (Coccinella bipunctata *L.*) in the Berlin Botanic Garden.

457. Chrysanthemum L.

Ray-florets yellow or white in colour; otherwise as Anthemis.

1480. C. segetum L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.' pp. 91–3, 159.)—The diameter of the golden-yellow heads of this species is 4–5 cm., of which a third is occupied by the disk. The 12–16 ray-florets are female: the stigma projects a little from the corolla-tube, which is 4 mm. long. The tongue is almost at right angles to this tube; its length is $1\frac{1}{2}$–2 cm. and its breadth

almost 1 cm. There are about 300 disk-florets. Each of these is 6–7 mm. long of which 2 mm. is taken up by the ovary, $2\frac{1}{2}$ by the corolla-tube, and 2 mm. by the bell of the corolla. In the first stage of anthesis the apposed stylar branches, covered with pollen, project from the bell; in the second stage the stigmatic inner surfaces of these branches protrude slightly. The diameter of the spinose pollen-grains is somewhat less than that of the median groove that traverses the stigmatic surface. The stylar branches of the ray-florets bear shorter sweeping-hairs than those of the disk-florets. It is noteworthy that in this species the upper surface of the bell of the corolla in both kinds of floret is beset with countless microscopic papillae. Should insect-visits fail the pollen falls automatically on the expanded stigmatic surfaces. Warnstorf (Verh. bot. Ver., Berlin, xxxvii, 1896) describes the pollen-grains as yellow in colour, usually ellipsoidal, closely spinose, on an average 37·5 μ long and 30 μ broad.

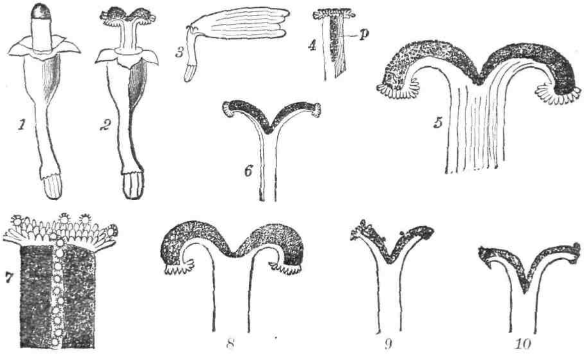


FIG. 202. 1–7. *Chrysanthemum segetum*, *L.* (from nature). (1) Disk-floret in the first (male) stage; pollen is issuing from the anther-cylinder. (2) Do. in the second (female) stage. (3) Female ray-floret. (4) Tip of the style of a disk-floret in the first (male) stage (with branches apposed), enlarged. *p*, stigmatic papillae. (5) Do. in the second (female) stage (with branches curving outwards), greatly enlarged. (6) Tip of the style of a ray-floret with diverging branches, enlarged. (7) Tip of stylar branch of a disk-floret, seen from within; in the middle is a groove mixed with pollen-grains; greatly enlarged.

8. *Anthemis arvensis*, *L.* (8) Tip of the style of a disk-floret with diverging and strongly recurved branches.

9. *Tanacetum Parthenium*, *L.* (9) As 8, but branches much less divergent; a few pollen-grains are seen.

10. *Matricaria Chamomilla*, *L.* (10) As 8, but branches less divergent.

VISITORS.—I observed the following in the island of Föhr and at Kiel.—

A. Diptera. (*a*) *Muscidae*: all skg.: 1. Lucilia caesar *L.*; 2. L. cornicina *F.*; 3. Scatophaga merdaria *L.*; 4. Sepsis cynipsea *L.* (*b*) *Syrphidae*: all skg. and po-dvg.; 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. E. tenax *L.*; 8. Helophilus pendulus *L.*; 9. Syritta pipiens *L.* **B. Hemiptera.** *Capsidae*: 10. Calocoris roseomaculatus *Deg.*; 11. Lygus pabulinus *L.*; 12. L. pratensis *F.* **C. Lepidoptera.** *Rhopalocera*: 13. Vanessa io *L.*, skg.

The following were recorded by the observers, and for the localities stated.—

Buddeberg observed the Sphegid Sapyga decemguttata *Jur.* ♂, skg. (according to Herm. Müller, 'Weit. Beob.,' III, p. 86). Alfken (Bremen), the po-dvg. Muscid Pyrellia cadaverina *L.* Scott-Elliot (Dumfriesshire), a parasitic humble-bee, 2 hover-flies, and 4 Muscids ('Flora of Dumfriesshire,' p. 94).

1481. **C. Leucanthemum** L. (=Leucanthemum vulgare *Lam.*, Tanacetum Leucanthemum *Sch. Bip.*). (Herm. Müller, 'Fertilisation,' pp. 329–31, 'Weit. Beob.,' III, p. 85, 'Alpenblumen,' p. 432; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893; Loew, 'Blütenbiol. Floristik,' pp. 394, 397; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 93, 195; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In this species the diameter of the yellow disk is 12–15 mm.; it is surrounded by a border of white ray-florets as broad or broader, so that the total width of the head is 40 mm. or more. Hermann Müller gives the length of the corolla of the 400–500 tubular florets as scarcely 3 mm.: the tongue of the usually 13 or 21 ray-florets (according to Ludwig) is 14–18 mm. long and 3–6 mm. broad. Nectar rises into the bell of the disk-florets, which is barely 1 mm. long. In the first stage of anthesis these florets present pollen, in the second stage their diverging stigmas to insects, so that these will necessarily effect numerous crossings during a single visit. The stylar mechanism is the same as in the last species (*cf.* Fig. 199, 6–8). There is also a similar possibility of automatic self-pollination: if the pollen has not been removed by insects from the sweeping-hairs it will fall from them upon the papillose stigmatic surfaces of the diverging stylar branches, so as to effect autogamy. Warnstorf describes the pollen-grains as yellow in colour, polyhedral, with strong spinose tubercles, 25–31 mm. in diameter.

Visitors.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Leptura livida *F.*, very numerous (H. M.); 2. L. testacea *L.* (H. M., Fichtelgebirge); 3. Pachyta octomaculata *F.* (H. M.); 4. Strangalia armata *Hbst.*, po-cltg. (H. M. and Budd., Thuringia); 5. S. atra *F.* (H. M.); 6. S. attenuata *L.* (H. M.); 7. S. melanura *L.*, freq. (H. M.). (*b*) *Chrysomelidae*: 8. Clytra quadripunctata *L.* (H. M., Kitzingen). (*c*) *Dermestidae*: 9. Anthrenus pimpinellae *F.*, po-dvg. (H. M.). (*d*) *Elateridae*: 10. Agriotes ustulatus *Schall.*, po-dvg. (H. M., Thuringia); 11. Athous niger *L.* (H. M.). (*e*) *Mordellidae*: 12. Mordella aculeata *L.*, freq. (H. M.); 13. M. fasciata *F.* (H. M.). (*f*) *Nitidulidae*: 14. Meligethes, very common (H. M.). (*g*) *Oedemeridae*: 15. Oedemera podagrariae *L.*, po-dvg. (H. M., Thuringia). (*h*) *Scarabaeidae*: 16. Cetonia aurata *L.* (H. M., Sauerland); 17. Gnorimus nobilis *L.* (H. M.); 18. Trichius fasciatus *L.*, freq. (H. M.). (*i*) *Telephoridae*: 19. Dasytes flavipes *F.* (H. M.); 20. Malachius aeneus *L.* (H. M.). (*k*) *Cleridae*: 21. Trichodes apiarius *L.* (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 22. Bombylius canescens *Mikan*, skg. (H. M., Budd.). (*b*) *Conopidae*: 23. Conops flavipes *L.*, skg. (H. M.); 24. Sicus ferrugineus *L.*, skg. (H. M.) (*c*) *Empidae*: 25. Empis rustica *F.*, skg. (H. M.). (*d*) *Muscidae*: 26. Echinomyia tessellata *F.* (H. M.); 27. Lucilia cornicina *F.* (H. M.); 28. L. sylvarum *Mg.* (H. M.); 29. Macquartia praefica *Mg.* (H. M.); 30. Musca corvina *F.* (H. M.); 31. Pollenia vespillo *F.*, po-dvg. and skg. (H. M.); 32. Pyrellia aenea *Zett.* (H. M.); 33. Scatophaga stercoraria *L.*, skg. (H. M.); 34. Sepsis sp., do. (H. M.). (*e*) *Stratiomyidae*: 35. Nemotelus pantherinus *L.*, extremely numerous, skg. (H. M.); 36. Odontomyia viridula *F.*, very common, skg. (H. M.). (*f*) *Syrphidae*: 37. Cheilosia fraterna *Mg.* (H. M.); 38. Eristalis aeneus *Scop.*, very common, po-dvg. (H. M.); 39. E. arbustorum

L., do. (H. M.); 40. E. horticola *Deg.*, do. (H. M., Sauerland); 41. E. nemorum *L.*, do. (H. M.); 42. E. sepulcralis *L.*, do. (H. M.); 43. Helophilus floreus *L.*, po-dvg. (H. M.); 44. H. pendulus *L.*, do. (H. M.); 45. Melithreptus taeniatus *Mg.*, po-dvg. (H. M.); 46. Paragus bicolor *F.*, po-dvg. (H. M., Budd.); 47. Pipiza lugubris *F.* (H. M.); 48. Syritta pipiens *L.*, skg. (H. M.); 49. Syrphus nitidicollis *Mg.*, po-dvg. (H. M.); 50. Volucella pellucens *L.* (H. M., Sauerland). **C. Hymenoptera.** (*a*) *Apidae*: 51. Andrena nigroaenea *K.* ♀, po-cltg. (H. M.); 52. A. schrankella *Nyl.* ♂, skg. (H. M., Budd.); 53. A. xanthura *K.* ♀, skg. (H. M.); 54. Bombus terrester *L.* ☿, skg. (H. M.); 55. Colletes daviesanus *K.* ♀ and ♂, very common, po-cltg. and skg. (H. M.); 56. Halictus albipes *F.* ♂, skg. (H. M.); 57. H. cylindricus *F.* ♀ and ♂, very common, skg. and po-cltg. (H. M.); 58. H. leucozonius *Schr.* ♀, po-cltg. (H. M.); 59. H. lugubris *K.* ♀, do. (H. M., Budd.); 60. H. maculatus *Sm.* ♀ and ♂, numerous, skg. and po-cltg. (H. M.); 61. H. rubicundus *Chr.* ♀, po-cltg. (H. M.); 62. H. villosulus *K.* ♀ and ♂, po-cltg. and skg. (H. M., Budd.); 63. Prosopis communis *Nyl.* ♀ (H. M.); 64. Sphecodes gibbus *L.* ♀ and ♂, all the vars. including ephippius *L.* (H. M., Budd.). (*b*) *Ichneumonidae*: 65. Several (H. M.). (*c*) *Sphegidae*: 66. Cerceris variabilis *Schr.* (H. M.); 67. Crabro cephalotes *F.* ♀ (H. M.); 68. C. cribrarius *L.* ♂, in large numbers (H. M.); 69. C. dives *H.-Sch.* ♂ (H. M., Budd.); 70. Oxybelus trispinosus *F.* (H. M.); 71. O. uniglumis *L.*, freq. (H. M.). (*d*) *Tenthredinidae*: 72. Abia sericea *L.* (H. M.); 73. Allantus nothus *Klg.*, skg. (H. M.); 74. A. scrophulariae *L.* (H. M.); 75. Several undetermined sp. of Tenthredinids (H. M.) **D. Lepidoptera.** (*a*) *Noctuidae*: 76. Anarta myrtilli *L.*, skg. (H. M.). (*b*) *Rhopalocera*: 77. Epinephele janira *L.*, do. (H. M.); 78. Hesperia thaumas *Hfn.*, do. (H. M.); 79. Melitaea athalia *Esp.*, do. (H. M.); 80. Pieris napi *L.*, do. (H. M.); 81. Polyommatus phlaeas *L.*, do. (H. M.); 82. Syrichthus alveolus *Hb.*, do. (H. M.). (*c*) *Sphingidae*: 83. Ino statices *F.*, freq. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands), Apis, 2 Bombus, one other bee, 7 Syrphids, 4 Muscids, and 2 Lepidoptera: also (Thuringia) the following ('Blütenbiol. Beob. in Thüringen').—**A. Coleoptera.** All po-dvg.: 1. Judolia cerambyciformis *Schr.*; 2. Leptura maculicornis *Deg.*; 3. Strangalia melanura *L.*; 4. Trichius fasciatus *L.*, freq. **B. Diptera.** (*a*) *Muscidae*: all skg.: 5. Anthomyia sp.; 6. Aricia basalis *Zett.*; 7. Hydrotaea sp. (*b*) *Syrphidae*: all skg. and po-dvg.: 8. Melithreptus sp.; 9. Syrphus annulipes *Zett.* ♀; 10. Volucella pellucens *L.* **C. Lepidoptera.** 11. Epinephele janira *L.*, skg.; 12. Zygaena trifolii *Esp.*, do.: also (Helgoland) 2 Muscids, po-dvg. (Lucilia caesar *L.* and Scatophaga stercoraria *L.*) (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 40). Alfken (Bremen), a bee (Eriades truncorum *L.* ♂, skg.) and a bug (Calocoris roseomaculatus *Deg.*, very common, skg.). Krieger (Leipzig), a bee (Halictus zonulus *Sm.*), a Sapygid (Sapyga clavicornis *L.*), and a Sphegid (Cerceris labiata *F.*). Warnstorf (Brandenburg), numerous small Staphylinid beetles, transferring pollen. Loew (Silesia), the beetle Meligethes sp. ('Beiträge,' p. 31): and (Riesengebirge) a Conopid (Conops quadrifasciatus *Deg.*), a bee (Prosopis armillata *Nyl.* ♀, skg.), and a butterfly (Melanargia galatea *L.*, skg.). Rossler (Wiesbaden), the Tineid Butalis laminella *H.-Sch.* von Fricken (Westphalia and E. Prussia), the Chrysomelid Cryptocephalus vittatus *F.*, freq. Loew (Switzerland), the Empid Empis tessellata *F.* Herm. Müller (Switzerland), 6 beetles, 20 flies, a bug, 7 Hymenoptera, and 34 Lepidoptera ('Alpenblumen,' pp. 432–4). Delpino (Florence), the Bombyliid Lomatia beelzebub *F.* ('Ult. oss.,' Atti Soc. ital. sc. nat., Milano, xvii). Schletterer (Tyrol), the carpenter-bee Xylocopa violacea *L.* Kohl (Tyrol), the fossorial wasp Crabro cribrarius *L.* MacLeod (Pyrenees), 3 Hymenoptera, a Lepidopterid, 3 beetles, and 21 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 360–2); also (Flanders) 5 Hymenoptera, 6 hover-flies, 14 other flies, 6 Lepidoptera, and 7 beetles (op. cit., v, 1893, pp. 425–6). Scott-Elliot (Dumfriesshire), 4 Muscids ('Flora of Dumfriesshire,' p. 93).

Ludwig found a slug (Limax laevis *Müller*) in hundreds on the heads in wet weather. (*Cf.* Vol. I, pp. 79–80.)

Clessin also observed (according to von Jhering) a slug (Limax brunneus *Drap.*) as an occasional agent of cross-pollination in Rio Grande do Sul.

458. Doronicum Tourn.

Disk-florets hermaphrodite; stylar branches, immediately below their extreme tip, surrounded by a circlet of sweeping-hairs directed obliquely upwards, the outermost being the longest; their inner surface completely beset with stigmatic papillae. Ray-florets ligulate, female, the outer ones almost devoid of sweeping-hairs.

1482. **D. macrophyllum** Fisch. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 25–6, Taf. II, Figs. 18–28.)—Hildebrand states that in this Persian species there is not such a perfectly adapted arrangement of sweeping-hairs as in most other Compositae, less because of the structure of the style itself than from the fact that when the pollen is shed its tip is already some distance above the base of the anther-cylinder. The ray-florets possess vestiges of the five stamens, and their nectaries are as well developed as those of the disk-florets.

Visitors.—Loew observed an Elaterid (Limonius cylindricus *Payk.*) and a bee (Halictus cylindricus *F.* ♀, po-cltg.) in the Berlin Botanic Garden.

1483. **D. Pardalianches** L.—Hildebrand (loc. cit.) states that this species resembles the last one. Here again the ray-florets possess vestigial stamens, and their nectaries are as well developed as those of the hermaphrodite florets. According to Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), the pollen-grains are golden-yellow in colour, spherical to ellipsoidal, with long spinose tubercles, 25–31 μ in diameter.

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Dermestidae*: 1. Anthrenus scrophulariae *L.* (*b*) *Nitidulidae*: 2. Meligethes aeneus *F.*, numerous. **B. Diptera.** (*a*) *Muscidae*: 3. Anthomyia sp.; 4. Lucilia caesar *L.* (*b*) *Syrphidae*: 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. Helophilus floreus *L.*; 8. H. pendulus *L.*; 9. Platycheirus albimanus *F.* ♂; 10. Syritta pipiens *L.* **C. Hymenoptera.** *Apidae*: 11. Chelostoma nigricorne *Nyl.* ♂, skg.; 12. Heriades truncorum *L.* ♀, po-cltg.; 13. Osmia fulviventris *Pz.* ♀, do.

1484. **D. cordatum** Sch. Bip. (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In this species the ray-florets are female; their stigmas mature before those of the hermaphrodite disk-florets. The latter develop in centripetal order, and the stamens of the outermost ones are usually vestigial. The pollen-grains are dark-yellow in colour, rounded to ellipsoidal, with long spines, 30–7 μ in diameter.

1485. **D. austriacum** Jacq.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia quadripunctata *L.* (*b*) *Nitidulidae*: 2. Meligethes sp. **B. Diptera.** (*a*) *Muscidae*: 3. Lucilia caesar *L.* (*b*) *Syrphidae*: 4. Eristalis arbustorum *L.*; 5. E. nemorum *L.*; 6. Helophilus floreus *L.*; 7. Syritta pipiens *L.* **C. Hymenoptera.** (*a*) *Apidae*: 8. Andrena fasciata *Wesm.* ♂, skg.; 9. Halictus cylindricus *F.* ♀, po-cltg.; 10. H. leucozonius *Schr.* ♀, do.; 11. H.

sexnotatus *K.* ♀, do.; 12. Heriades truncorum *L.* ♂ skg., ♀ po-cltg.; 13. Megachile centuncularis *L.* ♂, skg.; 14. Osmia fulviventris *Pz.* ♀, po-cltg.; 15. Prosopis armillata *Nyl.* ♀ and ♂, skg.; 16. P. communis *Nyl.* ♂, do.; 17. Sphecodes ephippius *L.* ♀, do.; 18. S. gibbus *L.* ♀, do.; 19. Stelis aterrima *Pz.* ♀, do.; 20. S. phaeoptera *K.* ♀, do. (*b*) *Tenthredinidae*: 21. Cephus sp. ♂. **D. Lepidoptera.** *Rhopalocera*: 22. Pieris brassicae *L.*, skg.

1486. **D. caucasicum** Bieb.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. (*a*) *Coccinellidae*: 1. Coccinella bipunctata *L.* (*b*) *Nitidulidae*: 2. Meligethes sp. **B. Diptera.** *Syrphidae*: 3. Eristalis aeneus *Scop.* **C. Hymenoptera.** *Apidae*: 4. Andrena nitida *Fourcr.* ♀, skg. and po-cltg.; 5. Apis mellifica *L.* ☿, skg. and po-cltg.; 6. Halictus nitidiusculus *K.* ♀, po-cltg.

1487. **D. plantagineum** L.—

Visitors.—Loew observed a Dermestid (Anthrenus scrophulariae *L.*), a bee (Halictus leucozonius *Schr.* ♀, po-cltg.), and a Sphegid (Cerceris variabilis *Schr.* ♀) in the Berlin Botanic Garden.

459. Aronicum Neck.

The tip of the style in disk-florets closely beset externally with long pointed *sweeping-hairs, internally (including the swollen margin) with stigmatic papillae. Style of ray-florets similar, but sweeping-hairs shorter.*

1488. **A. Clusii** Koch (including A. glaciale *Reichb.*). (Herm. Müller. 'Alpenblumen,' pp. 437–8.)—This species is gynomonoecious with protandrous hermaphrodite florets. The orange-yellow heads possess a disk 14–20 mm. in diameter, which is extended to 40–60 mm. by the ray-florets.

In the variety A. glaciale *Reichb.* (=the species Doronicum glaciale *Nym.*), according to Kerner ('Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 322), the receptive stigmas of the outer florets are brought into the line of fall of the pollen of the inner ones by *gradual elevation of the common receptacle, so that automatic geitonogomy is effected. Kerner adds that the stigmas of the ray-florets are mature several days before the hermaphrodite florets of the same head open.*

Visitors.—Herm. Müller observed 11 flies, a bee, and 5 Lepidoptera.

1489. **A. scorpioides** DC.—Kerner says that this species behaves like the last in regard to geitonogamy.

Visitors.—MacLeod (Pyrenees) observed a Lepidopterid and 2 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 360).

460. Ligularia Cass.

1490. **L. macrophylla** DC. (=Senecio Ledebourii *Sch. Bip.*).—

Visitors.—Loew observed the bee Megachile centuncularis *L.* ♀, po-cltg., in the Berlin Botanic Garden.

1491. **L. speciosa** Fisch. et Mey. (=Senecio Ligularia *Hook.*).—

Visitors.—Loew observed the bee Coelioxys elongata *Lep.* ♀, skg., in the Berlin Botanic Garden.

461. Arnica Rupp.

Ray-florets, female, ligulate; disk-florets, hermaphrodite, tubular. Style of the latter covered on their whole outer surface, including the somewhat expanded tip, with stiff sweeping-hairs directed obliquely upwards; closely beset internally with stigmatic papillae. Styles of the ray-florets devoid of sweeping-hairs.

1492. A. montana L. (Herm. Müller, 'Alpenblumen,' p. 436; Warnstorf, Verh. bot. Ver., Berlin, xxxvii, 1896; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 93, 159–60.)—In this species the diameter of the orange-coloured heads is 7 cm. in the North Frisian Islands, almost a third of this being taken up by the disk. Each of the 50–90 disk-florets possesses a corolla-tube 4 mm. long, expanding into a bell 5 mm. deep, with teeth 1 mm. in length. The pollen pressed out of the anther-cylinder projects from the bell during the first stage of anthesis; during the second the style with its branches, which gradually roll back in a circle. There are about 20 ray-florets with a corolla-tube 5 mm. deep, and a tongue 2–2½ cm. long and 5–7 broad. The style projects from the former, its branches being at first apposed, but subsequently diverging and displaying the stigmatic papillae.

Hermann Müller made similar observations in the Alps. He also found 50–90 disk-florets, making up a surface about 20 mm. in diameter, and about 20 ray-florets increasing the breadth of the head to 60–70 mm. Warnstorf adds that the rounded yellow pollen-grains are closely covered with spinose tubercles, and measure 31 μ in diameter on an average. When they are thrust out of the anther-cylinder of a disk-floret by the apposed stylar branches they fall upon the teeth of the corolla, which are beset at the edge with large blunt papillae that hold them fast. Soon after the two long stylar branches have emerged from the anther-cylinder they diverge, and roll back so that they not only reach the pollen-grains of the same floret with their inner (stigmatic) surfaces, but frequently bring these into contact with the pollen of the neighbouring florets. Automatic self-pollination and geitonogamy are therefore both possible.

Kerner also states that autogamy ultimately takes place by the rolling back of the stylar branches.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands and at Tondern), 3 bees, 5 Lepidoptera, 10 flies, and a beetle. Herm. Müller (Alps), 3 beetles, 5 flies, 5 Hymenoptera, and 34 Lepidoptera. Loew (Switzerland), a Muscid (Spilogaster duplicata *Mg.*), and a Syrphid (Cheilosia antiqua *Mg.*) ('Beiträge,' p. 58). Kriechbaumer (Alps), the parasitic humble-bee Psithyrus quadricolor *Lep.* ♂. Schiner (Austria), the Muscid Tephritis arnicae *L.* Schletterer (Tyrol), the Alpine humble-bee Bombus alticola *Krchb.*, and the parasitic humble-bee Psithyrus quadricolor *Lep.* The former was also seen (Tyrol) by von Dalla Torre.

1493. A. alpina Olin et Landau.—This species is native to Greenland, arctic America, Siberia, Spitzbergen, and Lapland. It is slenderer and more delicate than A. montana. The involucral bracts are often purple-red at their tips or entirely so; the bright-yellow ray-florets are generally twice as long as the involucre, but are sometimes only of the same length (Abromeit, 'Bot. Ergeb. von Drygalski's Grönlandsexped.,' pp. 69–70). In Spitzbergen the species blooms from the beginning

of September, and fruiting specimens have been observed (by Nathorst, 17. 8. '82. The pollen is abundant, and normally developed (Andersson and Hesselman, 'Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 10).

1494. **A. Chamissonis** Less.—

VISITORS.—Loew observed 2 Syrphids (Eristalis aeneus *Scop.*, and E. tenax *L.*) and 2 bees (Heriades truncorum *L.* ♀, po-cltg.; and Megachile centuncularis *L.* ♀, do.) in the Berlin Botanic Garden.

462. Cacalia L.

1495. **C. hastata** L.—The heads of this species exhale a strong odour of honey.

VISITORS.—Knuth observed the following (12. 9. '97) in the Kiel Botanic Garden; all (except 5 and 7) very freq., and all skg. ('Blütenbiol. Notizen').—

A. Diptera. *Syrphidae*: 1. Eristalis intricarius *L.*; 2. E. tenax *L.*; 3. Syrphus corollae *F.*; 4. S. ribesii *L.*; 5. Volucella pellucens *L.*, occasional. **B. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.* ☿; 7. Bombus agrorum *F.* ♀, occasional; 8. B. lapidarius *L.* ♂: 9. B. terrester *L.* ♀. **C. Lepidoptera.** *Rhopalocera*: 10. Vanessa io *L.*; 11. V. urticae *L.*

463. Senecio L.

LITERATURE.—Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 27–8, Taf. II, Figs. 29–36 (S. populifolius).

Ray-florets female, ligulate, yellow in colour, sometimes wanting; disk-florets hermaphrodite, tubular, yellow. Stylar branches with an apical bundle of sweeping-hairs, quite covered with stigmatic papillae internally and marginally.

1496. **S. vulgaris** L. (Herm. Müller, 'Fertilisation,' p. 336, 'Weit. Beob.,' III, p. 90; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 94, 'Bloemenbiol. Bijdragen.')—Ligulate ray-florets are wanting in this species. Hermann Müller says that there are 60–80 florets in a single head, with corolla-tubes $3\frac{1}{2}$–4 mm. in length and bells 1–$1\frac{1}{2}$ mm. long. Nectar ascends into the bell and is therefore very easily accessible. Owing to the small size of the heads (only 4 mm. in diameter) and the fact that the plant is not very conspicuous, insect-visits are few. The pollen-grains brushed out of the anther-cylinder by the sweeping-hairs which form a tuft at the end of the stylar branches, partly remain clinging to the marginal papillae when the branches diverge, and partly fall on their stigmatic inner surfaces. It follows that automatic self-pollination regularly takes place, and this is certainly effective. Bateson found, however, that plants resulting from cross-pollination were larger and more fertile than those produced by autogamy.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth, on one occasion, a hover-fly (Melanostoma mellina *L.*) po-dvg. Herm. Müller, during a period of 15 years, not infrequently saw a hover-fly (Syritta pipiens *L.*) and a bug (Pyrrhocoris apterus *L.*, skg.). Buddeberg (Nassau), 2 bees (Halictus morio *F.* ♀, skg.; and Heriades truncorum *L.* ♂, do.). Verhoeff (Norderney), the hover-fly Syritta pipiens *L.* MacLeod (Flanders), 4 Hymenoptera, 5 Syrphidae, 4 Muscidae, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 427–8, vi, 1894, p. 374). Scott-Elliot (Dumfriesshire), a Muscid ('Flora of Dumfriesshire,' p. 97). Burkill (Yorkshire coast), a Muscid (Anthomyia sp.) ('Fertlsn. of Spring Fls.').

1497. S. viscosus L.—Kerner says that the stylar branches in this species ultimately roll back in a semicircle so far that their stigmatic papillae touch the pollen which remains clinging to the elongated pappus-hairs of the same floret.

VISITORS.—Buddeberg observed the bee Panurgus calcaratus *Scop.* ♀ skg. and po-cltg., ♂ skg. (Herm. Müller, 'Weit. Beob.,' III, p. 90).

1498. S. sylvaticus L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 94.)—The diameter of the yellow heads of this species is only 5 mm. The few ray-florets (9–12) possess very small tongues, which roll up in dry weather. The disk-florets number about 40, and are 8 mm. in length, including the ovary, which is 2 mm. long. The stylar branches, only the tips of which are covered with sweeping-hairs, roll back in a semicircle during the second stage of anthesis, so that the pollen-grains still clinging to the collecting-hairs fall upon the exposed stigmatic papillae, thus effecting automatic self-pollination if crossing has not already taken place.

VISITORS.—Buddeberg (Oberpfalz) saw 2 po-dvg. flies (Echinomyia magnicornis *Zett.*, and Melithreptus scriptus *L.*) (Herm. Müller, 'Weit. Beob.,' III, p. 90).

Sickmann (Osnabrück) records the fossorial wasp Mellinus arvensis *L.*

1499. S. Doronicum L. (Herm. Müller, 'Alpenblumen,' pp. 438–40.)—In this species 100–200 female florets form an orange-yellow disk 10–20 mm. in diameter. The ray-florets, about 20 in number, extend this to a star 36–58 mm. broad. The male stage of the disk-florets lasts only for a very short time, for the outermost row spread out their stylar branches before those adjoining them have opened. The female stage persists longer, the stigmas of the outermost florets being still receptive, when the central ones are just entering on this stage. Kerner says that geitonogamy is possible, as in Aronicum glaciale, by the swelling up of the common receptacle (*cf.* p. 630).

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller, a beetle, 14 flies, 4 Hymenoptera, and 39 Lepidoptera. Loew (Switzerland), Merodon cinereus *F.*; also (Berlin Botanic Garden) 3 bees—1. Heriades truncorum *L.* ♀, po-cltg.; 2. Osmia fulviventris *Pz.* ♀, do.; 3. Stelis phaeoptera *K.* ♂, skg.

1500. S. paludosus L.—

VISITORS.—Heinsius (Wageningen) observed the hover-fly Eristalis horticola *Deg.* ♂, and the beetle Meligethes aeneus *F.*

1501. S. nemorensis L. (Herm. Müller, 'Weit. Beob.,' III, p. 90, 'Alpenblumen,' pp. 440–1.)—

The heads in this species are made up of 10–13 disk-florets and 5–6 ray-florets, and their total diameter is only 4–6 mm. As, however, 20–30 or even more heads are aggregated into a loose corymb, the plant is moderately conspicuous. Kerner states that automatic self-pollination may be effected by the rolling back of the stylar branches.

VISITORS.—Herm. Müller observed 4 flies, 4 bees, and 10 Lepidoptera in the Alps; and the following in Central Germany.—

A. Diptera. (*a*) *Conopidae*: 1. Conops scutellatus *Mg.*, skg. (*b*) *Leptidae*: 2. Leptis tringaria *L.*, skg. (*c*) *Muscidae*: 3. Aricia sp.; 4. Echinomyia fera *L.*, skg. (?).

(*d*) *Syrphidae*: 5. Eristalis pertinax *Mg.*, po-dvg.; 6. Volucella inanis *L.*, do.; 7. Xylota sp., do. **B. Hymenoptera.** (*a*) *Apidae*: 8. Bombus hypnorum *L.* ♂, skg.; 9. B. muscorum *F.* ♀ and ☿, do.; 10. B. pratorum *L.* ♀ and ☿, do.; 11. B. terrester *L.* ♂ (Thuringia); 12. Halictus cylindricus *F.* ♂, skg.; 13. H. lucidus *Schenck* ♀ and ♂, do.; 14. Psithyrus quadricolor *Lep.* ♂, do.; 15. P. vestalis *Fourcr.* ♂, do. (*b*) *Vespidae*: 16. Vespa rufa *L.* ☿. **C. Lepidoptera.** *Rhopalocera*: 17. Erebia ligea *L.*, skg.

Frey saw the Tortricid moth Grapholitha hepaticana *Tr.* in the Alps. Loew observed the hover-fly Cheilosia canicularis *Pz.* in the Riesengebirge ('Beiträge,' p. 51), and the following in the Berlin Botanic Garden.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella quattuordecimpunctata *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Echinomyia fera *L.*; 3. E. tessellata *F.*; 4. Pyrellia cadaverina *L.*; 5. Sarcophaga albiceps *Mg.*; 6. S. carnaria *L.* (*b*) *Syrphidae*: 7. Eristalis aeneus *Scop.*; 8. E. arbustorum *L.*; 9. E. nemorum *L.*; 10. E. sepulcralis *L.*; 11. E. tenax *L.*; 12. Syritta pipiens *L.*; 13. Syrphus balteatus *Deg.*; 14. S.

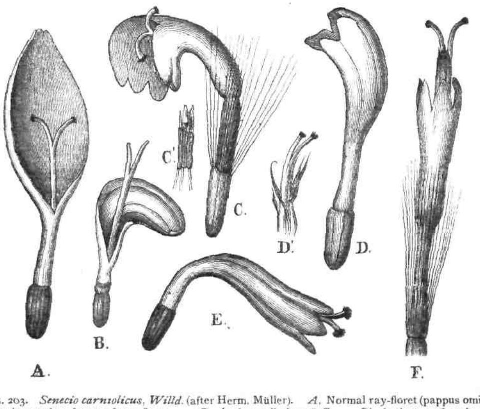


FIG. 203. *Senecio carniolicus, Willd.* (after Herm. Müller). *A.* Normal ray-floret (pappus omitted). *B-E.* Various other forms of ray-floret. *C'.* Anther-cylinder of *C.* *D'.* Anthers and style of *D.* *F.* Normal disk-floret (ovary omitted).

cinctellus *Zett.*; 15. S. ribesii *L.* **C. Hymenoptera.** (*a*) *Apidae*: 16. Apis mellifica *L.* ☿, skg. and po-cltg.; 17. Bombus terrester *L.* ♂, skg.; 18. Halictus sp. ♂, do.; 19. Heriades truncorum *L.* ♀, po-cltg.; 20. Prosopis armillata *Nyl.* ♂, skg.; 21. Stelis phaeoptera *K.*, do. (*b*) *Sphegidae*: 22. Ammophila sabulosa *L.* **D. Lepidoptera.** *Rhopalocera*: 23. Pieris brassicae *L.*, skg.

1502. S. saracenicus L. (Knuth, 'Blütenbiol. Herbstbeob.')—

VISITORS.—I observed Apis, Vanessa io *L.*, and 2 hover-flies (Eristalis nemorum *L.*, and Syritta pipiens *L.*), all skg., in the Kiel Botanic Garden.

1503. S. Fuchsii C. C. Gmel.—Kerner states that autogamy may be effected in this species in the same way as in S. nemorensis.

VISITORS.—Loew saw the butterfly Polyommatus phlaeas *L.*, skg., in the Berlin Botanic Garden.

1504. **S. carniolicus** Willd. (Herm. Müller, 'Alpenblumen,' pp. 441–2.)—In this species the diameter of the heads is 20–30 mm., and 3–10 of them are aggregated into a corymb. Each head consists of 5–10 disk-florets, and usually 3–5 ray-florets, though the latter may be entirely wanting. The ray-florets are remarkable as showing transitions to the tubular disk-florets (*cf.* Fig. 203).

VISITORS.—Herm. Müller observed a beetle, 3 flies, and 2 Lepidoptera.

1505. **S. cordatus** Koch (=S. alpinus *Scop.*, and Cineraria cordifolia *Gouan*). (Herm. Müller, 'Alpenblumen,' p. 442.)—In this species there are 150–200 disk-florets, making up a surface 12–18 mm. in diameter, which is extended by more than 20 ray-florets to form a star 50–60 mm. broad. The flower mechanism agrees with that of S. Doronicum, as in which the common receptacle swells up and renders geitonogamy possible (Kerner).

VISITORS.—Herm. Müller observed 2 flies and 2 Lepidoptera; and von Dalla Torre saw the Alpine humble-bee Bombus alticola *Kriechb.* in the Tyrol.

1506. **S. abrotanifolius** L. (Herm. Müller, 'Alpenblumen,' pp. 442–3.)—In this species the heads are 25–35 mm. in diameter, and as many are aggregated to form a continuous surface the plant is very conspicuous. The disk is 8–10 mm. broad, and contains 60–80 florets. The stylar branches of these diverge so widely in the second stage of anthesis that they almost touch the upper end of the anther-cylinder, but Hermann Müller never observed automatic self-pollination.

VISITORS.—Herm. Müller observed 2 beetles, 7 flies, 18 Lepidoptera, and a Hemipterid. It is noteworthy that the orange-red flowers are specially sought out by red butterflies (*cf.* Crepis aurea and Hieracium aurantiacum).

1507. **S. nebrodensis** L.—Kerner's investigations on the Blaser in the Tyrol prove that this usually annual species may continue to live on if its seeds are not able to ripen during the first year.

VISITORS.—Herm. Müller saw 8 flies, 5 bees, and 11 Lepidoptera in the Alps ('Alpenblumen,' p. 444).

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp. (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*; 3. E. nemorum *L.*; 4. Syritta pipiens *L.* **B. Hemiptera.** 5. Pyrrhocoris apterus *L.* **C. Hymenoptera.** *Apidae*: 6. Halictus nitidiusculus *K.* ♀, po-cltg.

1508. **S. macrophyllus** Bieb.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella bipunctata *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Echinomyia fera *L.*; 3. Pyrellia cadaverina *L.*; 4. Sarcophaga carnaria *L.* (*b*) *Syrphidae*: 5. Eristalis arbustorum *L.*; 6. E. nemorum *L.*; 7. Helophilus floreus *L.*; 8. H. trivittatus *F.*; 9. Syritta pipiens *L.* **C. Hymenoptera.** *Apidae*: 10. Apis mellifica *L.*, ☿, skg. and po-cltg.; 11. Halictus cylindricus *F.* ♀, skg.; 12. Psithyrus vestalis *Fourcr.* ♂, do.

1509. **S. Jacobaea** L. (Herm. Müller, 'Fertilisation,' pp. 335–6, 'Weit. Beob.,' III, p. 89; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 94, 160; MacLeod, Bot.

Jaarb. Dodonaea, Ghent, iii, 1891, v, 1893.)—This is gynomonoecious like the other species. Hermann Müller states that the disk is 7–10 mm. in diameter, and consists of 60–80 florets with corolla-tubes $2\frac{1}{2}$–3 mm. long, and bells of the same length. The 12–15 ray-florets increase the breadth of the head to about three times that of the disk. Since the heads are aggregated into a moderately dense cyme, the plant is conspicuous, and insect visitors are correspondingly numerous.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Coleoptera. *Oedemeridae*: 1. Oedemera virescens *L.*, po-dvg. (H. M.). **B. Diptera.** (*a*) *Conopidae*: 2. Zodion cinereum *F.*, skg. (Budd.). (*b*) *Empidae*: 3. Empis livida *L.*, very common, skg. (H. M.). (*c*) *Muscidae*: 4. Aricia incana *Wiedem.*, skg. (H. M.); 5. Gymnosoma rotundata *L.* (Budd.); 6. Lucilia sp., skg. (H. M.); 7. Oliviera lateralis *Pz.*, very numerous, skg. (H. M.); 8. Onesia floralis *R.-D.*, skg. (H. M.); 9. O. sepulcralis *Mg.*, do. (H. M.); 10. Phasia analis *F.* (Budd.); 11. P. crassipennis *F.* (Budd.); 12. Pollenia rudis *F.*, skg. (H. M.). (*d*) *Mycetophilidae*: 13. Sciara thomae *L.*, skg. (H. M.). (*e*) *Stratiomyidae*: 14. Odontomyia viridula *F.*, very common, skg. and po-dvg. (H. M.). (*f*) *Syrphidae*: 15. Ascia podagrica *F.*, do. (H. M.); 16. Cheilosia barbata *Loew*, do. (Budd.); 17. C. praecox *Zett.*, very common (Borgstette, Tecklenburg); 18. C. soror *Zett.* (H. M.); 19. Eristalis aeneus *Scop.*, very common, skg. and po-dvg. (H. M.); 20. E. arbustorum *L.*, do. (H. M., Budd.); 21. E. nemorum *L.* do. (H. M.); 22. E. sepulcralis *L.*, do. (H. M.); 23. E. tenax *L.*, do. (H. M.); 24. Paragus tibialis *Fall.*, skg. and po-dvg. (Budd.); 25. Syritta pipiens *L.*, very common, do. (H. M., Budd.). **C. Hymenoptera.** (*a*) *Apidae*: 26. Andrena denticulata *K.* ♀, po-cltg. (H. M.); 27. A. dorsata *K.*, do. (Budd.); 28. A. fulvicrus *K.* ♀, do. (H. M.); 29. Apis mellifica *L.*, do. (H. M.); 30. Bombus lapidarius *L.* ☿ and ♂, skg. and po-cltg. (H. M.); 31. B. pratorum *L.* ☿ and ♂, do. (H. M.); 32. Halictus albipes *F.* ♂, skg. (H. M.); 33. H. cylindricus *F.* ♀ and ♂, do. (H. M., Budd.); 34. H. longulus *Sm.* ♂, po-cltg. (Budd.); 35. H. maculatus *Sm.* ♂, do. (H. M.); 36. H. malachurus *K.* ♀, po-cltg. (Budd.); 37. H. nitidus *Schenck* ♂, skg. (H. M.); 38. H. villosulus *K.* ♀, skg. and po-cltg. (Budd.); 39. H. zonulus *Sm.* ♀, po-cltg. (Budd.); 40. Heriades truncorum *L.*, ♀ and ♂, skg. and po-cltg. (H. M., Budd.); 41. Nomada ferruginata *K.* ♀, skg. (H. M.); 42. N. furva *Pz.* ♀, do. (H. M.); 43. N. jacobaeae *Pz.* ♂, in large numbers, skg. (Budd.); 44. N. varia *Pz.* ♀, do. (H. M.); 45. N. zonata *Pz.* ♀, skg. (H. M.); 46. Osmia spinulosa *K.* ♀, po-cltg. (H. M., Thür.); 47. Psithyrus campestris *Pz.* ♂, skg. (H. M.). (*b*) *Tenthredinidae*: 48. Tarpa cephalotes *F.* (H. M., Thuringia). **D. Hemiptera.** 49. Capsus sp., skg. (H. M.). **E. Lepidoptera.** (*a*) *Rhopalocera*: 50. Epinephele hyperanthus *L.*, skg. (H. M.); 51. Melitaea athalia *L.*, do. (Budd.); 52. Polyommatus phlaeas *L.*, do. (H. M.). (*b*) *Sphingidae*: 53. Sesia asiliformis *Rott.*, skg. (H. M., Thuringia).

Willis observed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. (*a*) *Cryptophagidae*: 1. Antherophagus nigricornis *F.*, po-dvg. (*b*) *Nitidulidae*: 2. Meligethes sp., freq., po-dvg. **B. Diptera.** (*a*) *Bibionidae*: 3. Bibio pomonae *F.*, freq., skg.; 4. Dilophus sp., skg. (*b*) *Muscidae*: 5. Anthomyia radicum *L.*, freq., skg. and po-dvg.; 6. Calliphora erythrocephala *Mg.*, skg.; 7. Hyetodesia incana *Wied.*, do.; 8. Lucilia caesar *L.*, freq., skg.; 9. L. sericata *Mg.*, do.; 10. Morellia sp., skg.; 11. Mydaea sp., freq., skg. and po-dvg.; 12. Oliviera lateralis *F.*, freq., skg.; 13. Phytomyza geniculata *Macq.*, po-dvg.; 14. Sarcophaga carnaria *L.*, skg.; 15. Scatophaga stercoraria *L.*, freq., skg.; 16. Trichophthicus cunctans *Mg.*, skg. (*c*) *Syrphidae*: 17. Aretophila mussitans *F.*, skg.; 18. Cheilosia sp., do.; 19. Eristalis aeneus *Scop.*, freq., skg. and po-dvg.; 20. E. horticola *Deg.*, do.;

21. E. pertinax *Scop.*, do.; 22. Helophilus pendulus *L.*, skg.; 23. Sphaerophorea scripta *L.*, skg. and po-dvg.; 24. Syrphus balteatus *Deg.*, po-dvg.; 25. S. ribesii *L.*, po-dvg.; 26. S. topiarius *Mg.*, skg. **C. Hemiptera.** 27. Acocephalus sp.; 28. Anthocoris sp., freq.; 29. Calocoris bipunctatus *F.*, freq. **D. Hymenoptera.** (*a*) *Apidae*: 30. Andrena nigriceps *K.*, skg.; 31. Apis mellifica *L.*, freq., skg.; 32. Bombus agrorum *F.*, do.; 33. B. cognatus *Steph.*, skg.; 34. B. hortorum *L.*, freq., skg.; 35. B. lapidarius *L.*, skg.; 36. B. pratorum *L.*, freq., skg.; 37. Halictus albipes *K.*, do.; 38. H. rubicundus *Chr.*, do.; 39. Psithyrus quadricolor *Lep.*, do. (*b*) *Formicidae*: 40. Myrmica rubra *L.*, do. (*c*) *Ichneumonidae*: 41. Several sp. (*d*) *Vespidae*: 42. Odynerus pictus *Curt.*, skg. **E. Lepidoptera.** All skg.: (*a*) *Microlepidoptera*: 43. Crambus sp., freq.; 44. Choreutis myllerana *F.*; 45. Plutella cruciferarum *Zett.*; 46. Simaëthis fabriciana *Steph.*, freq. (*b*) *Noctuidae*: 47. Charaeas graminis *L.* (*c*) *Rhopalocera*: 48. Epinephele janira *L.*; 49. Pieris rapae *L.*; 50. Polyommatus phlaeas *L.*, freq.; all skg.

Alfken and Höppner (H.) saw the following bees at Bremen.—

1. Andrena convexiuscula *K.* ♀, rare; 2. A. denticulata *K.* ♀; 3. A. fuscipes *K.* (H.); 4. Coelioxys elongata *Lep.* ♀, skg.; 5. Colletes picistigma *Ths.* ♀ (H.); 6. Dufourea halictula *Nyl.* ♀ (H.); 7. Eriades nigricornis *Nyl.* ♀ and ♂; 8. E. truncorum *L.* ♀; 9. Halictus calceatus *Scop.* ♀ and ♂, very common, skg. and po-cltg.; 10. H. flavipes *F.*, very common, skg. and po-dvg.; 11. H. morio *F.*, not infrequent; 12. Nomada jacobaeae *Pz.* ♀ and ♂, freq., skg.; 13. Stelis breviuscula *Nyl.* ♂. (*b*) *Sphegidae*: 14. Crabro (Entomognathus) brevis *v. d. L.* ♀ and ♂.

Schenck gives the following bees for Nassau.—

1. Andrena carbonaria *L.*; 2. A. denticulata *K.*; 3. A. flavipes *Pz.*, 2nd gen.; 4. Colletes fodiens *K.*; 5. Epeolus variegatus *L.*; 6. Eriades truncorum *L.*; 7. Halictus albipes *F.* ♂; 8. H. calceatus *Scop.*; 9. H. flavipes *F.*; 10. H. levigatus *K.* ♂; 11. H. nitidiusculus *K.*; 12. H. pauxillus *Schenck* ♀ and ♂; 13. H. rubicundus *Chr.* ♂; 14. H. tetrazonius *Klg.* ♂; 15. Nomada furva *Pz.*; 16. N. jacobaeae *Pz.*; 17. N. lineola *Pz.*; 18. N. rhenana *Mor.*; 19. N. roberjeotiana *Pz.*; 20. N. ruficornis *L.*; 21. N. sexfasciata *Pz.* ♀ and ♂; 22. N. solidaginis *Pz.*; 23. N. zonata *Pz.*; 24. Osmia spinulosa *K.*

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands and Kiel), Apis, a Bombus, 4 Syrphids, and 3 Muscids. Gerstäcker (Berlin), 2 fossorial wasps (Oxybelus lineatus *Dahlb.*, and O. sericatus *Lep.*). Wüstnei (Alsen), 2 bees (Andrena listerella *K.*, in this species only, and Nomada roberjeotiana *Pz.*). Alfken (Juist), a fossorial wasp (Mellinus arvensis *L.*, rare), a butterfly (Hipparchia semele *L.*), and a Noctuid moth (Plusia gamma *L.*). Sickmann (Osnabrück), the following fossorial wasps,—1. Crabro cribrarius *L.*, very common; 2. C. scutellatus *Schev.*; 3. C. sexcinctus *F.*, rare; 4. C. vagus *L.*; 5. C. wesmaëli *v. d. L.*, infrequent; 6. Gorytes mystaceus *L.*, freq.; 7. G. quadrifasciatus *F.*, freq.; 8. Pompilus viaticus *L.*, very common; 9. Salius exaltatus *F.*, do.; 10. S. notatus *Lep.*, freq. Schmiedeknecht (Thuringia), the following bees—1. Andrena listerella *K.*; 2. A. nigripes *K.*; 3. Nomada brevicornis *Mocs.*; 4. N. fabriciana *L.*, 2nd gen.; 5. N. ferruginata *K.*; 6. N. fucata *Pz.*, 2nd gen.; 7. N. jacobaeae *Pz.*; 8. N. rhenana *Mor.*; 9. N. roberjeotiana *Pz.* Friese (Baden (B.) and Mecklenburg (M.)), 4 bees—1. Halictus calceatus *Scop.* (B.) ♂, not infreq.; 2. Nomada fucata *Pz.* (M.), 2nd gen.; 3. N. jacobaeae *Pz.* (M.), not infreq.; 4. N. solidaginis *Pz.* (M.), occasional. Rössler (Wiesbaden), 2 Tortricid moths (Grapholitha hepaticana *Tr.*, and G. trigeminana *Steph.*). Schletterer and von Dalla Torre (Tyrol), 3 humble-bees (1. Bombus hortorum *L.* ♀ and ☿; 2. B. mastrucatus *Gerst.* ☿; 3. B. soroënsis *F.* ☿) and a bee (Andrena collinsona *K.* ♂). Loew (Brandenburg), the bee Nomada jacobaeae *Pz.* ♀, skg. ('Beiträge,' p. 40); also Silesia (op. cit., p. 32).—**Hymenoptera.** (*a*) *Apidae*: 1. Andrena fulvicrus

K. ♂ and ♀, skg., ♀ also po-cltg. (*b*) *Chrysididae*: 2. Hedychrum lucidulum *F.* (*c*) *Sphegidae*: 3. Ammophila sabulosa *L.* ♀, skg.; 4. Crabro cribrarius *L.* ♀, skg.; 5. Psammophila viatica *Deg.* ♀, skg. H. de Vries (Netherlands), the bee Colletes fodiens *K.*, and the bumble-bee Bombus terrester *L.* (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). MacLeod (Flanders), 5 hover-flies and 2 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 427): also (Pyrenees), a bee, a hover-fly, and 2 Muscids (op. cit., iii, 1891, p. 360). Scott-Elliot (Dumfriesshire), 2 humble-bees, 3 short-tongued bees, several flies, and a beetle ('Flora of Dumfriesshire,' p. 98). Saunders (S.) and Smith (Sm.) (England), 7 bees (1. Andrena denticulata *K.* (S.); 2. A. tridentata *K.* (S., Sm.); 3. Colletes fodiens *K.* (S., Sm.); 4. Halictus calceatus *Scop.* ♂ (Sm.); 5. Nomada jacobaeae *Pz.* (S., Sm.); 6. N. roberjeotiana *Pz.* (S., Sm.); 7. N. solidaginis *Pz.* (S., Sm.)), and a fossorial wasp (Oxybelus mucronatus *F.*).

1510. **S. vernalis** Waldst. et Kit.—

VISITORS.—*Loew observed a beetle* (*Meligethes sp.*) *and a Muscid* (*Onesia floralis R.-D.*) in Brandenburg ('Beiträge,' p. 40).

1511. **S. vulgaris** L. × **S. vernalis** Waldst. et Kit. (Warnstorf, Schr. natw. Ver., Weringerode, xi, 1896.)—In this hybrid the diameter of the heads is about 10–12 mm. (in S. vernalis 22–25 mm.); 8–12 small ray-florets (in S. vernalis 12–13), with a semi-tubular tongue about 4 mm. long, spoon-shaped and concave above, 3-toothed, with prominent marginal papillae. In S. vernalis the tongue is flat from its base, 8–10 mm. in length, slightly emarginate at its rounded tip, and not papillose at the edges. The pollen-grains of the hybrid are golden-yellow in colour, very irregular, and variable in size. They are roundish to ellipsoidal, closely beset with spinose tubercles, 23–24 μ in diameter. Those of S. vernalis are regular, on an average 37 μ long and 24 μ broad. The tongues of the ray-florets do not roll up towards evening in the case of the hybrid, or only partly so, while those of S. vernalis all roll back strongly. After the pollen has been shed the disk-flowers of the hybrid are very soon exceeded in length by the pappus.

Warnstorf considers that the ray-florets of this hybrid are undoubtedly metamorphosed 5-toothed disk-florets, which represent an intermediate stage between the two kinds of floret. This also appears from the fact that a fourth tooth is sometimes visible immediately above the tubular part of the tongue, though as a rule two teeth fuse to form the tube, while the elongated spoon-shaped region possesses three teeth at its truncate end.

1512. **S. erucifolius** L.—*According to Kirchner* ('Beiträge,' p. 70), *the flower* mechanism of this species is the same as in S. Jacobaea. The total diameter of the head is about 30 mm., that of the disk 10 mm. The number of ray-florets is 12–14. The stylar branches of the disk-florets curve downwards to such an extent when they begin to fade at the end of the second stage of anthesis that they touch the undivided part of the style.

VISITORS.—Kirchner observed the hover-fly Eristalis tenax *L.*, and Schenck the following bees in Nassau.—

1. Epeolus variegatus *L.*; 2. Nomada jacobaeae *Pz.*; 3. N. roberjeotiana *Pz.*; 4. N. ruficornis *L.*; 5. N. sexfasciata *Pz.*; 6. N. solidaginis *Pz.*; 7. N. zonata *Pz.*

1513. **S. uniflorus** All.—Kirchner ('Beiträge,' p. 70) says that at Zermatt the diameter of the heads of this species is 30 mm. The number of ray-florets is 12–15.

The mechanism of the numerous disk-florets agrees with that of related species: their stylar branches do not curve back for more than a semicircle towards the end of anthesis, so that automatic self-pollination cannot take place.

1514. **S. aquaticus** Hill.—

Visitors.—Heinsius (Holland) observed 2 Muscids (Lucilia cornicina *F.* ♀, and Scatophaga stercoraria *L.* ♂ and ♀) and a Syrphid (Eristalis tenax *L.*).

In Dumfriesshire, a hover-fly and 5 Muscids were recorded (Scott-Elliot, 'Flora of Dumfriesshire,' p. 98).

464. Calendula L.

Ray-florets ligulate, female; stylar branches almost smooth externally, with a stigmatic line on each margin internally. Disk-florets tubular and male; end of the style conical and covered with sweeping-hairs, but no trace of stigmatic papillae. Kerner states that the stylar branches of the ray-florets curve till they touch the pollen of the disk-florets.

1515. **C. arvensis** L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 31–3, Taf. III, Figs. 10–17.)—This species is monoecious. Hildebrand says that the lower sweeping-hairs of the disk-florets are longer than the upper ones. Linnaeus observed at Upsala that the heads open at 9 a. m., closing again about noon.

Visitors.—Schletterer observed 2 bees (Andrena parvula *K.*, and Halictus calceatus *Scop.*) at Pola.

1516. **C. officinalis** L. (Hildebrand, op. cit., p. 33, Taf. III, Figs. 18–20.)—Hildebrand states that this species agrees in mechanism with the last one, but the tip of the style thickens abruptly and is covered with sweeping-hairs of nearly uniform length. According to Kerner, the stigmas of the female ray-florets become receptive before pollen is pressed out of the anther-cylinders of the male disk-florets. He noticed at Innsbruck that the heads open between 9 and 10 a. m., closing again between 4 and 5 p. m.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel Botanic Garden), Apis, a humble-bee (Bombus sylvarum *L.*), 3 hover-flies (1. Eristalis arbustorum *L.*; 2. E. tenax *L.*; 3. Syrphus ribesii *L.*), and a Muscid (Calliphora erythrocephala *Mg.*): all skg. ('Blütenbiol. Bijdragen'). Wüstnei (Alsen), 3 bees (1. Megachile centuncularis *L.*; 2. M. circumcincta *K.*; 3. Coelioxys acuminata *Nyl.*).

2. Sub-order Cynareae Less.

Stylar branches of the hermaphrodite florets usually combined into a pubescent bifid cylinder with a ring of hairs or swelling at their base. Otherwise as Corymbiferae.

465. Echinops L.

Stylar branches pubescent externally, with a ring of long sweeping-hairs at their base; papillose internally.

1517. **E. sphaerocephalus** L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 46–8, Taf. VI, Figs. 1–3; Herm. Müller, 'Fertilisation,' pp. 336–7, 'Weit. Beob.,' III, p. 79; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Herbstbeob.')—Hermann Müller says that the nectar rises into the bell after filling the corolla-tube (5–6 mm. long), which is almost completely occupied by the style. The bell is split almost to its base into five linear lobes, and the nectar is therefore accessible even to insects with a very short proboscis. After the style protrudes from the anther-cylinder, its branches still remain apposed for a time, so that the pollen may be removed by insect visitors before the stigmatic surfaces are spread out.

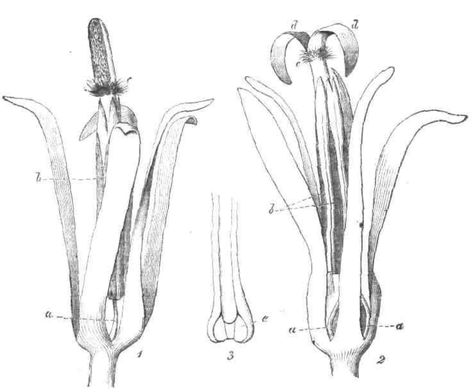


FIG. 204. *Echinops sphaerocephalus*, *L.* (after Herm. Müller). (1) Floret at the end of the first male) stage. (2) Do. in the second (female) stage. (3) Longitudinal section of the style and of the corolla-tube which surrounds it. *a*, filaments; *b*, anthers; *c*, brush of sweeping-hairs; *d*, stigma; *e*, nectary.

VISITORS.—I observed (Kiel Botanic Garden), Apis, skg., 2 humble-bees (Bombus lapidarius *L.* ☿ and ♀, skg., and B. terrester *L.* ♀, do.), 2 butterflies (Pieris sp., and Vanessa io *L.*), 2 hover-flies (Eristalis sp., and Syritta pipiens *L.*), and 2 Muscids (Lucilia cornicina *F.*, and Pollenia rudis *F.*). Loew saw Bombus terrester *L.* ♀, skg., in the Berlin Botanic Garden.

Herm. Müller (H. M.) and Buddeberg (Budd.) record the following for Thuringia and Nassau.—

Hymenoptera. (*a*) *Apidae*: 1. Bombus lapidarius *L.* ☿, skg. (H. M.); 2. B. muscorum *F.* ☿, do. (H. M.); 3. B. sylvarum *L.* ☿, do. (H. M.); 4. B. variabilis *Schmiedekn.* ☿, do. (Budd.); 5. Halictus cylindricus *F.* ♀ and ♂, very numerous, skg. (Budd.); 6. H. interruptus *Pz.* ♂, skg. (Budd.); 7. H. maculatus *Sm.* ♀, do. (Budd.); 8. H. minutissimus *K.* ♀, do. (Budd.); 9. H. morio *F.* ♀, do. (Budd.); 10. H. quadricinctus *F.* ♀ and ♂, do. (H. M.); 11. H. rubicundus *Chr.* ♂, do. (H. M.); 12. Prosopis communis *Nyl.* ♀, do. (Budd.). (*b*) *Vespidae*: 13. Polistes gallica *L.* (H. M.); 14. P. diadema *Ltr.*, freq., skg. (H. M.).

1518. E. Ritro L. (Sprengel, 'Entd. Geh.,' pp. 384–5; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The heads of this beautiful species are 5–6 cm. in diameter. The amethystine colour of those of the first order and the abundant supply of nectar cause many insects to be attracted. The florets develop in succession from the middle of the spherical heads downwards. The limb of the corolla in the tubular florets is divided almost to its base into 5 slender, bright blue lobes that spread out like a star above, while their white under-parts bulge outwards to form an ovoid or spherical nectar reservoir. This is partly covered and protected against rain by the hairy margins of the lobes. The blue tip of the style is densely covered with small hairs adapted to hold for a considerable time the pollen pushed out from the anther-cylinder, while the circlet of longer hairs immediately below the stylar branches serves to remove it from the cylinder. The stigmatic surfaces on the inner sides of the apposed stylar branches are quite undeveloped at this stage, and it is only several days later when they have become receptive that the branches diverge. The pollen has meanwhile been removed by insects or the wind, and the corolla-lobes bend upwards and erect themselves. It follows that insects can only effect crossing, transferring pollen from florets in the first (male) stage to others in the second (female) stage. The pollen-grains are white in colour, with low spinose tubercles, and of two kinds, rounded and about 56 μ in diameter, or ellipsoidal, and 88 μ long and 50 μ broad.

1519. E. bannaticus Rochel.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus albostriatus *Fall.*; 2. S. cinctellus *Zett.*; 3. S. corollae *F.* **B. Hymenoptera.** (*a*) *Apidae*: 4. Apis mellifica *L.* ☿, skg. and po-cltg.; 5. Bombus terrester *L.* ♂, skg. (*b*) *Sphegidae*: 6. Philanthus triangulum *F.* ♂.

1520. E. exaltatus Schrad.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Coleoptera. *Scarabaeidae*: 1. Cetonia aurata *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Chloria demandata *F.* (*b*) *Syrphidae*: 3. Eristalis nemorum *L.*; 4. Syrphus balteatus *Deg.*; 5. S. corollae *F.*; 6. S. pyrastri *L.* **C. Hymenoptera.** *Apidae*: 7. Apis mellifica *L.* ☿, skg. and po-cltg.; 8. Bombus hypnorum *L.* ☿, skg.; 9. B. terrester *L.* ♂ and ☿, skg. **D. Lepidoptera.** *Rhopalocera*: 10. Colias rhamni *L.*, skg.

466. Cirsium Adans.

Florets all tubular, hermaphrodite or dioecious. Stylar branches remain almost or entirely closed; covered with small pointed sweeping-hairs externally, with a ring of longer hairs at their base; their margins beset with stigmatic papillae.

1521. C. arvense Scop. (=Cnicus arvensis *Hoffm.*). (Herm. Müller, 'Fertilisation,' pp. 340–2, 'Weit. Beob.,' III, p. 81, 'Alpenblumen,' p. 422; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 94–5, 160, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins., p. 236, 'Bl. u. Insekt. a. d. Halligen,' 'Bloemenbiol. Bijdragen'; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893; Heinsius, op. cit., iv, 1892; Loew, 'Blütenbiol. Floristik,' pp. 390, 394).—

This species is gynodioecious. Hermann Müller states that there are more than 100 lilac-coloured florets in the hermaphrodite heads. The corolla-tubes are 8–12 mm. long, passing into bells 1–1½ mm. deep, with 5 linear slightly spreading lobes 4–5 mm. in length. Below, next the involucre, the head is scarcely 8 mm. in diameter, but above, where the corolla-lobes diverge, it is 20 mm. or more. As the plant usually bears numerous heads, it is very conspicuous, and the number of insect-visits is considerable. Visitors are the more numerous owing to the fact that the nectar rises as high as the bell of the corolla, so as to be accessible even to insects with a very short proboscis. The stylar branches are almost 2 mm. in length, and remain apposed even

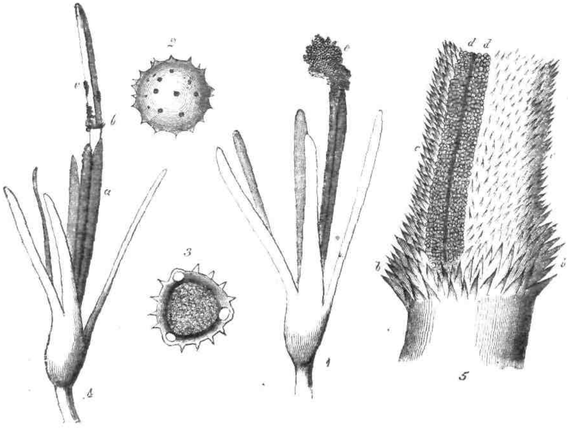


FIG. 205. *Cirsium arvense, Scop.* (after Herm. Müller). (1) Floret in the first (male) stage. (2) Pollen-grain in surface view (× 400). (3) Do. in optical section. (4) Floret in the second (female) stage: pollen still clinging to the style. (5) Uppermost part of the style (× 88). *a*, anther-cylinder; *b*, long sweeping-hairs; *c*, short do.; *d*, stigmatic papillae; *e*, pollen.

during the second stage of anthesis, only their margins, which are beset with stigmatic papillae, protruding. In the first stage a large quantity of pollen is swept out of the anther-cylinders. The sticky pollen-grains are beset with pointed outgrowths, and readily adhere to the hairy under-sides of insects creeping over the inflorescence: in favourable weather they are soon brushed away by visitors, so that crossing is assured. But if insects do not pay their visits till after the stigmatic papillae protrude, self-pollination may also occur. If such visits entirely fail, self-pollination may also be automatically effected by the fall of pollen-grains from the sweeping-hairs upon the stigmas. MacLeod states that the species is gynodioecious on the Blankenberg dunes, and Warnstorf says this is also the case at

Neu-Ruppin. Kerner describes the distribution of the sexes very aptly: pseudo-hermaphrodite fruiting- and pollen-flowers upon different stocks.

VISITORS.—I observed the following in Schleswig-Holstein (S.-H.), Rügen (R.), the dunes of Helgoland (H.), and Thuringia (T.).—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Pachyta virginea *L.* (T.). (*b*) *Coccinellidae*: 2. Coccinella septempunctata *L.* (H.). (*c*) *Scarabaeidae*: 3. Trichius fasciatus *L.*, very common, po-dvg. or resting inertly on the inflorescences (T.). (*d*) *Telephoridae*: 4. Psilothrix cyanea *Ol.*, freq. (H.). **B. Diptera.** (*a*) *Muscidae*: all skg.: 5. Anthomyia sp. (T.); 6. Aricia incana *Wied.* (S.-H.); 7. Calliphora vomitoria *L.* (H.); 8. Coelopa frigida *Fall.* (H.); 9. Lucilia caesar *L.* (S.-H. and H.); 10. Nemotelus uliginosus *L.* (S.-H.); 11. Rivellia syngenesiae *Fbr.* (S.-H.); 12. Sarcophaga carnaria *L.* (S.-H.); 13. Scatophaga merdaria *L.* (S.-H.); 14. S. stercoraria *L.* (S.-H.). (*b*) *Syrphidae*: all skg.: 15. Eristalis aeneus *Scop.* ♂ (S.-H.); 16. E. arbustorum *L.* (S.-H.); 17. E. intricarius *L.* ♂ (S.-H.); 18. E. nemorum *L.* (S.-H.); 19. E. pertinax *Scop.* (S.-H.); 20. E. tenax *L.* (S.-H.); 21. Helophilus pendulus *L.* (S.-H.); 22. Melithreptus taeniatus *Mg.* (S.-H.); 23. Syritta pipiens *L.* (S.-H.); 24. Syrphus arcuatus *Fall.* ♀ (H.); 25. S. ribesii *L.* (S.-H.); 26. Volucella bombylans *L.*, var. plumata *Mg.* (T.); 27. V. pellucens *L.*, freq. (H.). **C. Hymenoptera.** (*a*) *Apidae*: all but 35 skg. and po-cltg.: 28. Anthophora quadrimaculata *Fbr.* ♀ (S.-H.); 29. Apis mellifica *L.* (S.-H. and R.); 30. Bombus agrorum *F.* ♀ (T.); 31. B. cognatus *Steph.* ☿ (T.); 32. B. lapidarius *L.* (S.-H. and T.); 33. B. soroënsis *F.*, var. proteus *Gerst.* ☿ (T.); 34. B. terrester *L.* (S.-H. and T.); 35. Psithyrus quadricolor *Lep.*, only skg. (T.). (*b*) *Sphegidae*: 36. Ammophila sabulosa *L.*, freq. (R.). (*c*) *Tenthredinidae*: 37. Allantus nothus *Klg.* (S.-H.). (*d*) *Vespidae*: 38. Odynerus parietinus *L.* (S.-H.); 39. O. trifasciatus *F.* ♂ (S.-H.); 40. Vespa vulgaris *L.* (S.-H.). **D. Lepidoptera.** All skg. (*a*) *Noctuidae*: 41. Plusia gamma *L.* (S.-H.). (*b*) *Rhopalocera*: 42. Argynnis adippe *L.* (T.); 43. Epinephele janira *L.* (T. and S.-H.); 44. Pieris brassicae *L.* (S.-H.); 45. P. napi *L.* (S.-H.); 46. P. rapae *L.* (S.-H.); 47. P. sp. (T.); 48. Polyommatus phlaeas *L.* (S.-H.); 49. Vanessa urticae *L.* (S.-H.). (*c*) *Sphingidae*: 50. Zygaena filipendulae *L.* (S.-H.).

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia (W.), Nassau (N.), Thuringia (T.), and the Bavarian Oberpfalz (O.).—

A. Coleoptera. (*a*) *Carabidae*: 1. Levia crux-minor *L.* (H. M., O.). (*b*) *Cerambycidae*: 2. Leptura testacea *L.*, po-dvg. (H. M., O.); 3. Strangalia melanura *L.*, po-dvg. (H. M., O.). (*c*) *Chrysomelidae*: 4. Cryptocephalus sericeus *L.*, resting inactively on the florets (H. M., O.). (*d*) *Cleridae*: 5. Trichodes apiarius *L.* (H. M., O.). (*e*) *Curculionidae*: 6. Bruchus sp. (H. M.); 7. Larinus jaceae *L.* (H. M., T.); 8. L. obtusus *Schh.* (H. M., O.). (*f*) *Elateridae*: 9. Agriotes gallicus *Lac.* (H. M., T.); 10. A. ustulatus *Schall.* (H. M., T.); 11. Corymbites holosericeus *Oliv.* (H. M., O.). (*g*) *Lycidae*: 12. Dictyoptera sanguinea *Scop.* (H. M., O.). (*h*) *Mordellidae*: 13. Mordella aculeata *L.*, freq. (H. M.); 14. M. fasciata *F.*, do. (H. M.). (*i*) *Oedemeridae*: 15. Oedemera podagrariae *L.*, po-dvg. (H. M., Kitzingen). (*k*) *Scarabaeidae*: 16. Cetonia aurata *L.*, dvg. the florets (H. M., O.); 17. Trichius fasciatus *L.* (H. M.). (*l*) *Telephoridae*: 18. Telephorus melanurus *F.*, extremely numerous, inserting its head into the corolla-bells (H. M.). **B. Diptera.** (*a*) *Bombyliidae*: 19. Anthrax flava *Mg.* (H. M., T.). (*b*) *Conopidae*: 20. Conops flavipes *L.* (H. M.); 21. C. quadrifasciatus *Deg.*, skg. (H. M., O.); 22. Physocephala rufipes *F.*, skg. (H. M., O. and W.). (*c*) *Empidae*: 23. Empis livida *L.*, skg. (H. M.). (*d*) *Muscidae*: 24. Lucilia cornicina *F.*, freq., skg. (H. M.); 25. L. sericata *Mg.* (H. M.); 26. Musca cornicina *F.*, freq., skg. (H. M.); 27. Ocyptera brassicaria *F.*, do. (H. M.); 28. O. cylindrica *F.*, do. (H. M.); 29. Olivieria lateralis *F.*, skg. (H. M.); 30. Onesia floralis *R.-D.* (H. M.); 31. Platystoma seminationis *F.* (H. M.); 32. Sarcophaga carnaria *L.*, skg. (H. M.).

(e) *Stratiomyidae*: 33. Odontomyia viridula *F.*, not infrequent, skg. (H. M. (f) *Syrphidae*: 34. Cheilosia oestracea *L.* (H. M., Fichtelgebirge); 35. Eristal aeneus *Scop.*, freq., skg. (H. M.); 36. E. arbustorum *L.*, do. (H. M.); 37. E. intri carius *L.*, do. (H. M.); 38. E. nemorum *L.* (H. M., W. and O.); 39. E. sepulcrali *L.*, do. (H. M.); 40. E. tenax *L.*, do. (H. M.); 41. Melithreptus taeniatus *Mg.*, do (H. M.); 42. Syritta pipiens *L.*, freq. (H. M.); 43. Syrphus sp., freq., skg. (H. M.) 44. Volucella inanis *L.*, po-dvg. (H. M., Fichtelgebirge); 45. V. pellucens *L.*, po-dvg (H. M., Fichtelgebirge); 46. V. bombylans *L.*, var. plumata *L.*, po-dvg. (H. M. Fichtelgebirge). (g) *Tabanidae*: 47. Tabanus bromius *L.* (H. M., O.); 48. T rusticus *L.* (H. M., T.). **C. Hymenoptera.** (a) *Apidae*: 49. Andrena dorsata *K.* ♀ and ♂, in large numbers, skg. (H. M.); 50. A. fulvicrus *K.* ♀, skg. (H. M.) 51. A. gwynana *K.* ♀ and ♂, freq., skg. (H. M.); 52. A. nana *K.* ♂, skg. (H. M.); 53. A. pilipes *F.* ♂, skg. (H. M.); 54. A. bimaculata *K.*, var. vitrea *Sm.* ♂ (H. M., Cassel); 55. Apis mellifica *L.*, in very large numbers, skg. and occasionally po-cltg. (H. M.); 56. Bombus hortorum *L.* ♂, skg. (H. M.); 57. B. lapidarius *L.* ☿, skg. (H. M.); 58. Cilissa leporina *Pz.* ♂, freq., skg. (H. M.); 59. Dasypoda hirtipes *F.* ♀ and ♂, skg. and po-cltg., ♂ freq. (H. M.); 60. Halictus albipes *F.* ♂, skg. (H. M., Budd.); 61. H. cylindricus *F.* ♀ and ♂, freq., skg. (H. M.); 62. H. flavipes *F.* ♀, skg. (H. M.); 63. H. longulus *Sm.* ♂, do. (H. M.); 64. H. maculatus *Sm.* ♀, do. (H. M., Budd.); 65. H. minutus *K.* ♀, do. (H. M.); 66. H. nitidiusculus *K.* ♂, do. (H. M.); 67. H. nitidus *Schenck* ♂, do. (H. M.); 68. H. rubicundus *Chr.* ♂, do. (H. M.); 69. H. tarsatus *Schenck* ♀, do. (H. M.); 70. Heriades truncorum *L.* ♀, do. (H. M.); 71. Macropis labiata *Pz.* ♂ (H. M., O.); 72. Nomada jacobaeae *Pz.* ♀ and ♂, freq., skg. (H. M.); 73. N. lineola *Pz.* ♀ and ♂, do. (H. M.); 74. N. fabriciana *L.*, var. nigrita *Schenck* ♂, skg. (H. M.); 75. N. roberjeotiana *Pz.* ♀ and ♂, do. (H. M.); 76. N. solidaginis *Pz.* ♀ and ♂, skg. (H. M.); 77. Prosopis communis *Nyl.* ♀, freq., skg. (H. M.); 78. P. confusa *Nyl.* ♀ and ♂, skg. (H. M.); 79. P. sinuata *Schenck* ♂, do. (H. M.); 80. P. variegata *F.* ♀ and ♂, freq., skg. (H. M., Budd.); 81. P. sp. ♂, skg. (H. M., O.); 82. Sphecodes gibbus *L.* ♀ and ♂, do.; represented by different varieties including ephippius *L.* (H. M.). (b) *Chrysididae*: 83. Hedychrum lucidulum *F.* ♀, skg. (H. M.). (c) *Ichneumonidae*: 84. Several sp. (H. M.). (d) *Sphegidae*: 85. Ammophila sabulosa *L.*, skg. (H. M.); 86. Bembex rostrata *L.* ♀, do. (H. M.); 87. Cerceris arenaria *L.* ♀ and ♂, not infrequent, skg. (H. M.); 88. C. nasuta *Dahlb.* ♀ and ♂, freq., skg. (H. M., Budd.); 89. C. variabilis *Schr.* ♀ and ♂, very common, skg. (H. M.); 90. Crabro alatus *Pz.* ♀ and ♂, very numerous (H. M.); 91. C. cribrarius *L.* ♀ and ♂, freq., skg. (H. M., W. and O.); 92. C. vagus *L.* ♂, skg. (H. M., O.); 93. Dinetus pictus *F.* ♀ and ♂, do. (H. M.); 94. Gorytes quinquecinctus *F.*, freq., skg. (H. M., O.); 95. Lindenius albilabris *F.* ♀ and ♂, skg. (H. M.); 96. Oxybelus trispinosus *F.* ♀, do. (H. M.); 97. O. uniglumis *L.* ♀ and ♂, freq., skg. (H. M.); 98. Philanthus triangulum *F.* ♂, skg. (H. M., W. and O.); 99. Salius sanguinolentus *F.*, skg. (H. M.). (e) *Tenthredinidae*: 100. Allantus nothus *Klg.*, skg. (H. M.); 101. Several undetermined species, do. (H. M.). (f) *Vespidae*: 102. Eumenes pomiformis *F.* ♀ (H. M., O.); 103. Polistes diadema *Ltr.* (H. M., O.). **D. Lepidoptera.** All skg. (a) *Noctuidae*: 104. Hydroecia nictitans *Bkh.*, var. erythrostigma *Haw.* (H. M.). (b) *Rhopalocera*: 105. Epinephele hyperanthus *L.* (H. M., Fichtelgebirge); 106. E. janira *L.* (H. M., Fichtelgebirge and W.); 107. Hesperia lineola *O.* (H. M., O.); 108. H. sylvanus *Esp.* (H. M.); 109. Pieris brassicae *L.*, freq. (H. M.); 110. Rhodocera rhamni *L.* (H. M.); 111. Thecla rubi *L.* (H. M.); 112. Vanessa urticae *L.* (H. M.). (c) *Sphingidae*: 113. Ino statices *L.* (H. M., Fichtelgebirge); 114. Zygaena carniolica *Scop.* (H. M., T.); 115. Z. minos *S.-V.* (H. M., Fichtelgebirge).

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 4 beetles, 6 flies, 8 Hymenoptera, and 15 Lepidoptera. Alfken (Juist).—**A. Coleoptera.** *Coccinellidae*: 1. Coccinella septempunctata *L.*

B. Diptera. (*a*) *Muscidae*: 2. Calliphora vomitoria *L.*; 3. Cynomyia mortuorum *L.*; 4. Lucilia caesar *L.*; 5. Nemoraea radicum *F.* (*b*) *Syrphidae*: 6. Eristalis arbustorum *L.*; 7. E. tenax *L.*, very common; 8. Syrphus pyrastri *L.* **C. Hymenoptera.** (*a*) *Apidae*: 9. Bombus arenicola *Ths.* ☿, once; 10. B. hortorum *L.* ☿; 11. B. lapidarius *L.* ☿, freq.; 12. B. ruderatus *F.* ♂; 13. B. terrester *L.* ☿, freq. (*b*) *Sphegidae*: 14. Oxybelus mucronatus *F.*; 15. O. uniglumis *L.*, rare. **D. Lepidoptera.** (*a*) *Nymphalidae*: 16. Argynnis aglaia *L.*; 17. A. niobe *L.* (*b*) *Lycaenidae*: 18. Lycaena icaris *Rott.*; 19. Polyommatus phlaeas *L.* Verhoeff (Norderney).—**A. Diptera.** (*a*) *Muscidae*: 1. Calliphora erythrocephala *Mg.* ♀, not infrequent; 2. Cynomyia mortuorum *L.* ♀ and ♂; 3. Lucilia latifrons *Schin.*, very common; 4. Sarcophaga carnaria *L.*; 5. Scatophaga stercoraria *L.* ♀; 6. Stomoxys calcitrans *L.* ♀. (*b*) *Syrphidae*: 7. Eristalis arbustorum *L.* ♀, freq.; 8. E. tenax *L.* ♀, occasional; 9. Helophilus pendulus *L.* ♀; 10. Platycheirus manicatus *Mg.* ♀, occasional; 11. Syritta pipiens *L.*, occasional; 12. Syrphus balteatus *Deg.* ♂; 13. S. pyrastri *L.* ♂. **B. Hymenoptera.** (*a*) *Apidae*: 14. Bombus sylvarum *L.* ♂, occasional; 15. Psithyrus vestalis *Fourcr.* ♂; 16. Sphecodes cirsii *Verh.* ♂, occasional. (*b*) *Formicidae*: 17. Formica fusca *L.* ☿, freq. (*c*) *Vespidae*: 18. Odynerus parietum *L.* ♀ and ♂. Alfken (Bremen), a Muscid (Aricia basalis *Zett.*) and 11 bees—1. Andrena flavipes *Pz.* ♀; 2. A. nigriceps *K.* ♀; 3. Bombus agrorum *F.* ♂ and ☿; 4. B. derhamellus *K.* ♀ and ♂; 5. B. lapidarius *L.* ☿; 6. B. lucorum *L.* ♂; 7. B. proteus *Gerst.* ♂; 8. Osmia solskyi *Mor.* ♀; 9. Prosopis hyalinata *Sm.* ♀; 10. Psithyrus rupestris *F.* ♀, skg.; 11. P. vestalis *Fourcr.* ♂. Sickmann (Osnabrück), the fossorial wasp Passaloecus brevicornis *A. Mor.*, rare; (Wellingholthausen), do., and Cerceris arenaria *L.* Schmiedeknecht (Thuringia), the bee Andrena fumipennis *Schmiedekn.* ♂, and the humble-bee Bombus terrester *L.* ♂. Schenck (Nassau), the Sphegid Cerceris rybiensis *L.*, and 5 bees—1. Andrena austriaca *Pz.*; 2. A. florea *F.*; 3. Coelioxys conoidea *Ill.*; 4. Macropis labiata *F.*; 5. Prosopis hyalinata *Sm.* Loew (Silesia), the following ('Beiträge,' p. 31).—**A. Coleoptera.** (*a*) *Scarabaeidae*: 1. Cetonia aurata *L.*, dvg. the florets. (*b*) *Telephoridae*: 2. Rhagonycha melanura *F.* **B. Diptera.** (*a*) *Conopidae*: 3. Conops quadrifasciatus *Deg.* ♂ and ♀, skg. (*b*) *Muscidae*: 4. Nemoraea pellucida *Mg.*, skg.; 5. N. strenua *Mg.*, do. (*c*) *Stratiomyidae*: 6. Odontomyia hydroleon *L.*, skg.; 7. O. viridula *F.*, do. (*d*) *Syrphidae*: all skg.: 8. Eristalis intricarius *L.*; 9. E. nemorum *L.*; 10. Syritta pipiens *L.*; 11. Volucella bombylans *L.* **C. Hymenoptera.** (*a*) *Apidae*: 12. Apis mellifica *L.* ☿, skg. (*b*) *Chrysididae*: 13. Hedychrum lucidulum *Dahlb.*; 14. Holopyga amoenula *Dahlb.* (*c*) *Scoliidae*: 15. Scolia bicincta *Ross.* ♀ and ♂, skg. **D. Lepidoptera.** *Rhopalocera*: all skg.: 16. Hesperia comma *L.*, skg.; 17. Melanargia galatea *L.*, skg.; 18. Epinephele janira *L.*, skg.; 19. Pieris brassicae *L.*, skg.; (Brandenburg) (op. cit., p. 39),—**Diptera.** *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. tenax *L.*: (Brunswick) (op. cit., p. 50),—**Diptera.** *Syrphidae*: 1. Volucella bombylans *L.*; 2. V. pellucens *L.*, skg. Kohl, the fossorial wasp Crabro cribrarius *L.* Schletterer (Tyrol), the humble-bee Bombus lapidarius *L.*; (Pola), the bee Osmia fulviventris *Pz.* Schiner (Austria), the Muscid Trypeta ruficauda *F.* Heinsius (Holland).—**A. Diptera.** (*a*) *Empidae*: 1. Empis livida *L.* ♂ and ♀, very numerous. (*b*) *Muscidae*: 2. Scatophaga stercoraria *L.* ♀. **B. Hymenoptera.** (*a*) *Apidae*: 3. Apis mellifica *L.* ☿; 4. Macropis labiata *F.* ♂; 5. Psithyrus quadricolor *Lep.* ♂. **C. Lepidoptera.** *Rhopalocera*: 6. Vanessa io *L.*, persistently skg. H. de Vries (Netherlands), 2 humble-bees (Bombus subterraneus *L.*, and B. terrester *L.*) (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875. MacLeod (Flanders), 7 long-tongued bees, 6 short-tongued bees, a saw-fly, a ruby-wasp, 7 true wasps, 15 hover-flies, 12 other Diptera, 6 Lepidoptera, and 2 beetles (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 407–8): (Pyrenees), a humble-bee and a hover-fly (op. cit., iii, 1891, p. 350). Smith (England), the bee Macropis labiata *F.* Scott-Elliot (Dumfriesshire), a humble-bee, a saw-fly, a short-tongued bee, and several other bees ('Flora of Dumfriesshire,' p. 100).

1522. C. lanceolàtum Hill. (=Cnicus lanceolatus *Willd.*, and Carduus lanceolatus *L.*). (Herm. Müller, 'Fertilisation,' p. 343, 'Weit. Beob.,' III, p. 82; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 94, 169, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 236; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892; MacLeod, op. cit., iii, 1891, v, 1893; Loew, 'Blütenbiol. Floristik,' p. 390; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—The florets of this species are bright purple in colour. Hermann Müller states that their mechanism is similar to that of C. arvense. The nectar, however, is less accessible, for there is a bell 4–6 mm. deep at the end of the corolla-tube of 16–18 mm., so that to reach the nectar in the base of the latter a much longer proboscis is required. Warnstorf gives somewhat different measurements:—corolla-tube about 23 mm. long, and its limb, which possesses two deep incisions and three shallower ones, 11 mm.; the style with its branches projects 8 mm. beyond the retracted anther-cylinder, so that its total length is 42 mm. The pollen-grains are white in colour, spherical or ellipsoidal, coarsely spinose, about 56 μ in diameter. The species is consequently chiefly adapted to the visits of long-tongued bees.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list of visitors for Westphalia and Nassau.—

A. Diptera. (*a*) *Conopidae*: 1. Physocephala rufipes *F.*, skg. (H. M.). (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*, very common, po-dvg. and skg. (H. M.); 3. E. nemorum *L.*, do. (H. M.); 4. E. tenax *L.*, do. (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 5. Apis mellifica *L.* ☿, freq., skg. (H. M.); 6. Bombus agrorum *F.* ☿ and ♂, do. (H. M.); 7. B. lapidarius *L.* ☿ and ♂, do. (H. M.); 8. B. terrester *L.* ☿ and ♂, do. (H. M.); 9. Halictus cylindricus *F.* ♀ po-cltg., ♂ vainly trying to suck (Budd.); 10. H. maculatus *Sm.* ♀, po-cltg. (Budd.); 11. H. malachurus *K.* ♀, do. (Budd.); 12. H. tetrazonius *Klg.* ♀, do. (Budd.); 13. H. zonulus *Sm.* ♂, vainly trying to suck (Budd.); 14. Megachile maritima *K.* ♀, po-cltg. (H. M.); 15. Psithyrus campestris *Pz.* ♂, skg. (H. M.); 16. Stelis aterrima *Pz.* ♀, skg. (Budd.). (*b*) *Vespidae*: 17. Polistes gallica *L.*, freq., skg. (?) (H. M.); 18. P. diadema *Ltr.*, do. (H. M.). **C. Lepidoptera.** *Rhopalocera*: 19. Hesperia sp., skg. (H. M.); 20. Pieris brassicae *L.*, freq., skg. (H. M.); 21. P. napi *L.*, skg. (Budd.).

The following were recorded by the observers, and for the localities stated.—

Loew (Mecklenburg), the bee Megachile lagopoda *L.*, po-cltg. ('Beiträge,' p. 40). Knuth (Schleswig-Holstein).—**A. Diptera.** (*a*) *Muscidae*: all po-dvg.: 1. Lucilia caesar *L.* (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*; 3. E. nemorum *L.*; 4. E. tenax *L.* **B. Hymenoptera.** *Apidae*: all po-cltg. and skg.: 5. Apis mellifica *L.*; 6. Bombus cognatus *Steph.* ☿; 7. B. lapidarius *L.*; 8. B. terrester *L.* **C. Lepidoptera.** *Rhopalocera*: 9. Pieris brassicae *L.*, skg.: (Helgoland) (Bot. Jaarb. Dodonaea, Ghent, viii, 1896, p. 40).—**A. Coleoptera.** *Telephoridae*: 1. Psilothrix cyanea *Ol.* **B. Diptera.** *Muscidae*: 2. Coelopa frigida *Fall.*, po-dvg.; 3. Scatophaga stercoraria *L.*, do. **C. Lepidoptera.** *Rhopalocera*: 4. Pieris brassicae *L.*, skg. **D. Orthoptera.** 5. Forficula auricularia *L.*, dvg. the florets. Alfken (Juist), a bee (Bombus hortorum *L.* ♂, freq.), a Sphegid (Ammophila sabulosa *L.*), a butterfly (Pieris brassicae *L.*), and a moth (Plusia gamma *L.*): (Bremen), 6 bees—1. Bombus agrorum *F.* ♂; 2. B. hortorum *L.* ♀; 3. B. sylvarum *L.* ☿; 4. B. terrester *L.* ♂; 5. Megachile centuncularis *L.* ♀ and ♂; 6. Psithyrus rupestris *F.* ♀, skg. Herm. Müller (Alps), a beetle, 7 bees, and 8 Lepidoptera ('Alpenblumen,' pp. 425–6). Schenck (Nassau), the parasitic bee Coelioxys conoidea *Ill.* MacLeod (Pyrenees), 3 long-tongued bees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 349): (Flanders), Apis, 9 humble-bees, 3 hover-flies, and a Lepidopterid (op. cit., v, 1893, p. 404).

H. de Vries (Netherlands), the humble-bee Bombus agrorum *F.* ♂, and the parasitic humble-bee Psithyrus vestalis *Fourcr.* (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). Heinsius (Holland), a hover-fly (Eristalis horticola *Deg.* ♀), a bee (Halictus leucozonius *Schr.* ♀), and 2 butterflies (Epinephele janira *L.*, and Vanessa urticae *L.*). Scott-Elliot (Dumfriesshire), 2 humble-bees, another long-tongued bee, an Empid, 3 hover-flies, 2 Muscids, and a Lepidopterid ('Flora of Dumfriesshire,' p. 100).

1523. C. palustre Scop. (=Cnicus palustris *Willd.*). (Herm. Müller, 'Fertilisation,' pp. 343–4, 'Weit. Beob.,' III, pp. 82–3, 'Alpenblumen,' p. 425; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892; Loew, 'Blütenbiol. Floristik,' p. 394.)—This species is gynodioecious. Hermann Müller says that the purple-red florets are intermediate between those of the two last as regards accessibility of nectar (bell of corolla 2½ mm.), and, consequently, number of insect visitors. Female stocks are rarer than hermaphrodite ones. Warnstorf (Ver. bot. Ver., Berlin, xxxviii, 1896) adds that in the middle of the upper part of every outer involucral bract there is a swelling which secretes a sticky substance (of unknown function) during anthesis. The tube of the corolla is about 7 mm. long, as also is its limb, beyond which the style projects 4–5 mm. The upper parts of the filaments are hairy. The pollen-grains are white in colour, spheroidal, coarsely spinose, on an average 52 μ in diameter.

VISITORS.—Herm. Müller observed the following in Central and South Germany.—

A. Coleoptera. (*a*) *Cerambycidae*: 1. Strangalia melanura *L.*, freq. (Sauerland). (*b*) *Elateridae*: 2. Agriotes ustulatus *Schall.* (Sauerland). **B. Diptera.** (*a*) *Conopidae*: 3. Conops quadrifasciatus *Deg.*, occasional, skg.; 4. C. scutellatus *Mg.*, freq., skg.; 5. Sicus ferrugineus *L.*, skg. (*b*) *Muscidae*: 6. Echinomyia fera *L.* (*c*) *Syrphidae*: 7. Eristalis tenax *L.*, skg. and po-dvg.; 8. Rhingia rostrata *L.*; 9. Syrphus ribesii *L.*; 10. S. tricinctus *Fall.* po-dvg.; 11. Volucella bombylans *L.*, do.; 12. V. inanis *L.*, skg. and po-dvg.; 13. V. pellucens *L.*, do. **C. Hymenoptera.** (*a*) *Apidae*: 14. Andrena coitana *K.* ♀, skg.; 15. A. denticulata *K.* ♀, do.; 16. A. gwynana *K.* ♂, do.; 17. Apis mellifica *L.* ☿, very numerous, skg. and po-cltg.; 18. Bombus lapidarius *L.* ☿ and ♂, po-cltg. and skg.; 19. B. pratorum *L.* ♂, skg.; 20. B. rajellus *K.* ☿, do.; 21. Halictus cylindricus *F.* ♀ and ♂, very numerous, po-cltg. and skg.; 22. H. sp. ♂, skg.; 23. Heriades truncorum *L.* ♂, do.; 24. Megachile centuncularis *F.* ♂, do.; 25. M. maritima *K.* ♂, do.; 26. Psithyrus quadricolor *Lep.* ♂, freq., skg.; 27. P. vestalis *Fourcr.* ♀, skg. (*b*) *Sphegidae*: 28. Cerceris labiata *F.* ♂, vainly trying to suck; 29. Lindenius albilabris *F.* **D. Lepidoptera.** (*a*) *Noctuidae*: 30. Plusia gamma *L.*, not infrequent, skg. (*b*) *Rhopalocera*: 31. Argynnis paphia *L.*, persistently skg.; 32. Epinephele hyperanthus *L.*, skg.; 33. E. janira *L.*, do.; 34. Erebia ligea *L.*, freq., skg.; 35. Hesperia silvanus *Esp.*; 36. Pieris brassicae *L.*, numerous, skg.; 37. P. rapae *L.*, numerous; 38. Vanessa urticae *L.*, in large numbers, skg. (*c*) *Sphingidae*: 39. Zygaena minos *S.-V.*, skg.

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 5 bees and 6 Lepidoptera. Loew (Brunswick) ('Beiträge,' p. 50), 3 Chrysomelid beetles (1. Cryptocephalus bipunctatus *L.*; 2. C. moraei *L.*; 3. C. vittatus *F.*) and a Muscid (Herina frondeocentiae *L.*): (Silesia) (op. cit., p. 31), a hover-fly (Eristalis intricarius *L.*, skg.) and 2 hawk-moths (Zygaena achilleae *Esp.*, skg.; and Z. minos *S.-V.*, do.). Alfken (Bremen), 3 bees—1. Bombus agrorum *F.* ♂; 2. B. distinguendus *Mor.* ♀ and ☿; 3. Halictus zonulus *Sm.* ♀. Schmiedeknecht (Thuringia), 3 bees—1. Bombus hypnorum *L.* ♂; 2. B. pratorum *L.* ☿ and ♂; 3. Psithyrus quadricolor *Lep.*, freq. Hoffer (Steiermark), the parasitic bee Psithyrus quadricolor *Lep.* ♂. Schiner (Austria), 3 Muscids—1. Trypeta ruficauda *F.*; 2. T. winthemi *Mg.*; 3. Urophora stigma *Loew.* Schletterer (Tyrol), 3 bees—1. Megachile ligniseca *K.* (also

by von Dalla Torre); 2. M. pacifica *Pz.*; 3. Psithyrus quadricolor *Lep.* Heinsius (Holland).—**A. Diptera.** (*a*) *Empidae*: 1. Empis livida *L.* ♀. (*b*) *Syrphidae*: 2. Volucella bombylans *L.* ♂. **B. Hymenoptera.** *Apidae*: 3. Bombus agrorum *F.* ☿; 4. B. scrimshiranus *K.* ☿. **C. Lepidoptera.** *Rhopalocera*: 5. Vanessa urticae *L.* H. de Vries (Netherlands), the bees Bombus agrorum *F.* ♂ and Apis mellifica *L.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). MacLeod (Flanders), 13 long-tongued bees, 4 short-tongued bees, a fossorial wasp, 8 hover-flies, 2 Empids, and 7 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 404–5). Scott-Elliot (Dumfriesshire), 2 humble-bees, a true wasp, and a hover-fly ('Flora of Dumfriesshire,' p. 100).

1524. C. eriophorum Scop. (=Cnicus eriophorus *Roth*, and Carduus eriophorus *L.*).—MacLeod says that the nectar is very deeply concealed in the purple florets of this species ('Pyreneënbl.,' pp. 349–50). The tube of the corolla is 20 mm. long, and the bell 9 mm., with 5 lobes 4.5 in length. One of the five incisions between the lobes is about 2 mm. deeper than the other four, enabling a humble-bee to thrust its head for 1–2 mm. into the bell, and to reach the base of this if its proboscis is 7–8 mm. long. The deeply concealed nectar is only accessible to long-tongued bees and Lepidoptera.

Visitors.—The following were recorded by the observers, and for the localities stated.—

MacLeod (Pyrenees), only humble-bees (6 species). Herm. Müller (Thuringia), the long-tongued bee Megachile lagopoda *L.* ♀ po-cltg. and skg., ♂ skg.); (Alps), 2 humble-bees and 2 Lepidoptera ('Alpenblumen,' p. 425). Schiner (Austria), 2 Muscids—1. Trypeta acuticornis *Loew*; 2. Urophora eriolepidis *Loew*, very freq.

1525. C. heterophyllum Hill (=Cnicus heterophyllus *Roth*, and Carduus heterophyllus *L.*). (Herm. Müller, 'Alpenblumen,' pp. 424–5.)—In each head of this species there are 200–300 florets with red bells 8 mm. long. During the first stage of anthesis pollen is swept out of the anther-cylinder; during the second the stylar branches diverge a little at the end, and the papillose edges of their inner surfaces swell up to some extent. Failing insect-visits, automatic self-pollination is possible, for the stigmatic margins of the stylar branches project till they touch the pollen that remains clinging to the sweeping-hairs.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller, the humble-bee Bombus mesomelas *Gerst.*, skg. and po-cltg. Scott-Elliot (Dumfriesshire), 2 humble-bees and a hover-fly ('Flora of Dumfriesshire,' p. 101). Schneider (Arctic Norway), chiefly the humble-bee Bombus agrorum *F.* (Tromsø Mus. Aarsh., 1894). Loew (Berlin Botanic Garden).—**A. Coleoptera.** *Telephoridae*: 1. Dasytes flavipes *F.*, freq. **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg.; 3. Bombus hortorum *L.* ☿, persistently skg.; 4. Osmia fulviventris *Pz.* ♀, po-cltg.

1526. C. acaule Wigg. (=Cnicus acaulis *Willd.*, and Carduus acaulis *L.*). (Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896, pp. 38–9.)—Warnstorf describes the flower mechanism of this species for Neu-Ruppin, where the purple-red florets are always hermaphrodite. The tube of the corolla is 20–22 mm. long, and its limb as much as 15 mm. The latter is cleft by 3 incisions about 5–6 mm. deep, and 2 of about 10 mm., into 5 slender erect lobes, forming a sort of cap to the floret. The anther-cylinder possesses basal hair-like appendages, and when pollen is pressed out

of it from below by the apposed stylar branches, projects somewhat beyond the limb of the corolla. But when the style has completely elongated, the cylinder is withdrawn between the lobes of the corolla by contraction of the filaments. The outer surface of the stylar branches is densely covered with very short sweeping-hairs, which are scarcely to be seen even with the aid of a lens, except at the base of the branches, where they are somewhat larger. In the second stage of anthesis the margins of the inner surfaces of the stylar branches, which are beset with papillae, bend somewhat outwards, enabling insects to effect cross-pollination, or rendering autogamy possible should some pollen still cling to the sweeping-hairs. The pollen-grains are white in colour, roundish to ellipsoidal, coarsely spinose, as much as 63 μ in diameter.

In other localities the species is gynodioecious.

According to Ljungström (Bot. Not., Lund, 1884), the female stocks in Sweden bear smaller heads than the hermaphrodite ones.

Visitors.—The following were recorded by the observers and for the localities stated.—

Herm. Müller (Alps), 7 bees and 6 Lepidoptera ('Alpenblumen,' p. 422). Rössler (Wiesbaden), the Tineid moth Depressaria incarnatella *Zell.* MacLeod (Pyrenees), 2 humble-bees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 349–50).

1527. **C. rivulare** Link (=Cnicus rivularis *Willd.*).—

Visitors.—Hoffer records Bombus lapidarius *L.* ♂ for Steiermark.

1528. **C. oleraceum** Scop. (=Cnicus oleraceus *L.*). (Herm. Müller, 'Fertilisation,' p. 343; Knuth, 'Blütenbiol. Herbstbeob.,' 'Blütenbiol. Floristik,' pp. 260, 397; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—Warnstorf observed only hermaphrodite florets at Neu-Ruppin. The tube of the corolla is about 15 mm. long, and its limb 6–7 mm. The style projects 7–8 mm. from the tube. The anther-cylinder possesses hair-like appendages at its base, and the upper halves of the filaments are hairy. The pollen-grains are white in colour, roundish-ellipsoidal, coarsely spinose, up to 62 μ in diameter.

E. Köhne (Verh. bot. Ver., Berlin, xxviii, 1886, pp. 6–7) has published an interesting observation. He found in Pomerania that the yellowish-white heads were visited by very large numbers of the brimstone butterfly (Rhodocera Rhamni *L.*), which in colour and form of wings presents a certain agreement with the pale-yellow upwardly-directed tips of the involucral bracts. This would seem to be a case of special protective resemblance (*cf.* Vol. I, p. 144).

Visitors.—Herm. Müller (H. M.) in Westphalia and myself (Kn.) in Schleswig-Holstein observed the following.—

A. Hymenoptera. *Apidae*: all skg.: 1. Apis mellifica *L.* ☿ (Kn., H. M.); 2. Bombus agrorum *F.* (Kn.); 3. B. lapidarius *L.* (Kn.); 4. B. terrester *L.* ☿ and ♂ (H. M.); 5. Psithyrus vestalis *Fourcr.* (Kn.). **B. Lepidoptera.** (*a*) *Rhopalocera*: 6. Pieris sp. (Kn.) skg. (*b*) *Noctuidae*: 7. Euclidia glyphica *L.*, skg. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 3 humble-bees ('Alpenblumen,' p. 424). Loew (Alps), the Muscid Spilographa neigenii *Loew.* Wüstnei (Alsen), the humble-bee Bombus latreillellus *K.* Alfken (Bremen), 2 skg. humble-bees—Bombus arenicola *Ths.* ☿, and B. proteus *Gerst.* ♂. Schmiedeknecht (Thuringia), 2 bees—Psithyrus barbutellus *K.* ♂, and Osmia solskyi *Mor.* ♀. Hoffer (Steiermark), 2 bees—Bombus lapidarius *L.*

♂, and Psithyrus barbutellus *K.* ♂, very freq. Schletterer and von Dalla Torre (Tyrol), the bee Melecta luctuosa *Scop.* Loew (Berlin Botanic Garden), on the var. *amarantinum*, a beetle (Cetonia aurata *L.*, dvg. the florets), 2 hover-flies (Syrphus balteatus *Deg.*, and S. corollae *F.*), and 2 bees (Bombus pratorum *L.* ♂, and Psithyrus vestalis *Fourcr.* ♂).

1529. **C. oleraceum** *Scop.* × **C. acaule** Wigg. (= C. decoloratum *Koch*). (Warnstorf, Verh. bot. Ver., Berlin, xxxiii, 1896.)—This hybrid is gynodioecious. The flower mechanism is like that of C. acaule. The limb of the corolla is white or pale lilac in colour, and its tube about 10 mm. long. The stylar branches are white. The pollen-grains are white, rounded, spinose, about 50 μ in diameter.

Visitors.—Loew observed a bee (Psithyrus vestalis *Fourcr.* ♂, skg.) and a butterfly (Pieris brassicae *L.*, freq., skg.) in the Berlin Botanic Garden.

1530. **C. acaule** Wigg. × **C. oleraceum** Scop.—

Visitors.—Loew observed 2 bees (Bombus terrester *L.* ♂, skg.; and Psithyrus campestris *Pz.* ♂, do.) in the Berlin Botanic Garden.

1531. **C. oleraceum** Scop. × **C. palustre** Scop. (= C. hybridum *Koch* and C. lacteum *Koch*).—In this hybrid the leaves are not decurrent, and there are no glandular swellings on the involucral bracts. Warnstorf describes the pollen-grains as white in colour, spheroidal or ellipsoidal, and varying greatly in size (from 37 μ to 56 μ in diameter) (Verh. bot. Ver., Berlin, xxxviii, 1896).

1532. **C. spinosissimum** Scop. (Herm. Müller, 'Alpenblumen,' pp. 423–4.)—This species is very prickly, and bears a number of yellowish-white heads, the conspicuousness of which is increased by the involucral bracts being of the same colour. The corolla-tube is 8–9 mm. in length, and ends in a bell 4–5 mm. deep, with 5 lobes about 5 mm. long. The flower mechanism resembles that of C. heterophyllum.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 6 beetles, 6 flies, 15 Hymenoptera, and 14 Lepidoptera. Loew (Heuthal), a Hesperid (Hesperia comma *L.*, skg.), a Noctuid (Agrotis occelina *S.-V.*), and a hawk-moth (Zygaena exulans *Hchw. et Rein.*). von Dalla Torre (Ötzthaler Alps), the humble-bee Bombus mastrucatus *Gerst.* ♀. Schmiedeknecht (*teste* Morawitz) and von Dalla Torre and Schletterer (Tyrol), the bee Osmia confusa *Mor.* The last-named also records 3 humble-bees—1. Bombus alticola *Krchb.* ☿ (po-cltg. in the heaviest rain); 2. B. hortorum *L.* ♀; 3. the parasitic species Psithyrus globosus *Ev.*

1533. **C. ochroleucum** All. (= Cnicus ochroleucus *Spreng.*).—

Visitors.—Herm. Müller observed 4 humble-bees and a butterfly in the Alps ('Alpenblumen,' p. 425).

1534. **C. monspessulanum** Hill (= Cnicus monspessulanus *Roth*).—MacLeod (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 350–1) says that the stem of this species bears 3–4 purple-coloured heads, each 25–30 mm. in diameter. The tube of the corolla is 7–8 mm. in length, and the bell 6–7 mm. deep, with lobes 3–4 mm. long. A proboscis 6 mm. in length is therefore required to reach the nectar.

Visitors.—MacLeod (Pyrenees) observed 4 humble-bees, 9 Lepidoptera, and

3 Syrphidae. Loew noticed the butterfly Pieris brassicae *L.*, skg., in the Berlin Botanic Garden.

1535. C. glabrum DC. (=Cnicus spinosissimus *L.* (?)).—The heads of this species are yellowish-white in colour.

Visitors.—MacLeod (Pyrenees) saw the humble-bee Bombus hortorum *L.* ☿ (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 352).

1536. C. serrulatum Bieb. (=Cnicus serrulatus *Bieb*).—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Hymenoptera. (*a*) *Apidae*: 1. Psithyrus rupestris *F.* ♂, skg. (*b*) *Sphegidae*: 2. Ammophila sabulosa *L.* **B. Lepidoptera.** *Rhopalocera*: 3. Rhodocera rhamni *L.*, skg.; 4. Pieris brassicae *L.*, do.: and on the var. *ucranicum* Bess., 2 bees (Psithyrus campestris *Pz.* ♂, skg.; and P. vestalis *Fourcr.* ♂).

467. Kentrophyllum Neck.

1537. K. lanatum DC. et Duby (=Carthamus lanatus *L.*).—

Visitors.—Schletterer observed the rare bee Halictus quadrinotatus *K.*

468. Silybum Vaill.

Stylar branches covered externally by short sweeping-hairs, a ring of longer, usually somewhat oblique ones, at their base. They diverge only at the tip, during the second stage of anthesis.

1538. S. Marianum Gaertn. (=Carduus Marianus *L.*). (Sprengel, 'Entd. Geh.,' pp. 371–2.)—The florets of this species are purple-red in colour. Hildebrand states that the pollen-grains are sometimes imperfect in heads that mature early (U. d. Geschlechtsverhält. b. d. Compositen,' pp. 60–2).—

Visitors.—Buddeberg saw the following bees in Nassau (Herm. Müller, 'Weit. Beob.,' III, p. 81).—

1. Chelostoma nigricorne *Nyl.* ♂, skg.; 2. Halictus sexcinctus *F.* ♀, skg. and po-cltg.; 3. H. tetrazonius *Klg.* ♀, skg.; 4. Megachile fasciata *Sm.* ♂, skg.; 5. Osmia adunca *Panz.* ♂, do.; 6. O. fulviventris *Pz.* ♀, do.; 7. Stelis phaeoptera *K.* ♂, do.

469. Carduus L.

Florets tubular and hermaphrodite. Stylar branches diverge only at the tip; externally a ring of sweeping-hairs at their base; margins of inner surfaces (which appear at a later stage) beset with stigmatic papillae.

1539. C. crispus L. (Herm. Müller, 'Fertilisation,' pp. 338–9, 'Weit. Beob.,' III, p. 83; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 95, 161; Heinsius, Bot. Jaarb. Dodonaea, Ghent, iv, 1892; Loew, 'Blütenbiol. Floristik,' p. 395.)—Hermann Müller says that in this species 35–80 bright purple florets are aggregated into a head which is scarcely 10 mm. in diameter below, but they curve outwards in such a way that a red surface 25–30 mm. across is presented above. The corolla of each floret expands into a ventricose bell, 2½–3 mm. long, with linear slightly diverging lobes 4–5½ mm. in length. The flower mechanism agrees in other respects with that of the hermaphrodite florets of Cirsium arvense, but, owing to the depth of the

bell, the number of insects to which the nectar is accessible is necessarily more limited.

Purely female stocks were observed by Ljungström in Sweden (Bot. Not., Lund, p. 675).

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list.—

A. Diptera. (*a*) *Empidae*: 1. Empis livida *L.*, freq., skg. (Budd.). (*b*) *Muscidae*: 2. Cynomyia mortuorum *L.*, skg. (Budd.). (*c*) *Syrphidae*: 3. Eristalis arbustorum *L.*, skg. and po-dvg. (Budd.); 4. E. tenax *L.*, freq., skg. and po-dvg. (H. M.). **B. Hymenoptera.** *Apidae*: 5. Andrena gwynana *K.* ♀, skg. (Budd.); 6. Apis mellifica *L.*, ☿, freq., skg. (Budd.); 7. Bombus agrorum *F.*, do. (H. M. and Budd.); 8. B. lapidarius *L.* ☿ and ♂, do. (H. M. and Budd.); 9. B. terrester *L.* ♀, skg. (H. M. and Budd.); 10. Chelostoma nigricorne *Nyl.* ♂, do. (Budd.); 11. Coelioxys conoidea *Ill.* ♀, do. (Budd.); 12. Halictus albipes *F.* ♂, do. (Budd.); 13. H. cylindricus *F.* ♂ and ♀, do. (H. M. and Budd.); 14. H. leucozonius *Schr.* ♀, do. (Budd.); 15. H. sexnotatus *K.* ♀, do. (Budd.); 16. Megachile lagopoda *K.* ♂ and ♀, do. (Budd.); 17. Osmia fulviventris *Pz.* ♀, po-cltg. (H. M.); 18. Psithyrus barbutellus *K.* ♂, skg. (Budd.); 19. Stelis aterrima *Pz.* ♀, do. (H. M. and Budd.). **C. Lepidoptera.** (*a*) *Pyralidae*: 20. Eurycreon verticalis *L.*, skg. (H. M.). (*b*) *Rhopalocera*: 21. Hesperia comma *L.*, skg. (Budd.); 22. Melanargia galatea *L.*, freq., skg. (Budd.); 23. Pieris napi *L.*, skg. (H. M.); 24. P. rapae *L.* (H. M.). (*c*) *Sphingidae*: 25. Zygaena carniolica *Scop.*, freq. (Budd.); 26. Z. filipendulae *L.*, do. (Budd.); 27. Z. minos *S.-V.*, do. (Budd.).

The following were recorded by the observers, and for the localities stated.—

Knuth (Föhr), 4 bees, 3 Lepidoptera, and 2 hover-flies. Loew (Brandenburg), the Conopid Conops quadrifasciatus *Deg.*, skg. ('Beiträge,' p. 39). Wüstnei ('Marsch' of Schleswig-Holstein), the humble-bee Bombus cullumanus (*K.*) *Ths.*; Alfken (Bremen), the bee Megachile centuncularis *L.* ♀, skg. Schmiedeknecht (Thuringia), 2 humble-bees—Bombus soroënsis *F.* ♂, and B. confusus *Schenck.* H. de Vries (Netherlands), 3 humble-bees (1. Bombus hypnorum *L.* ♂; 2. B. subterraneus *L.* ♂; 3. B. terrester *L.* ♂), and 2 parasitic humble-bees (Psithyrus rupestris *F.* ♂, and P. vestalis *Fourcr.* ♂). Heinsius (Holland).—**A. Diptera.** (*a*) *Empidae*: 1. Empis livida *L.* ♂ and ♀. (*b*) *Muscidae*: 2. Scatophaga stercoraria *L.* ♂. (*c*) *Syrphidae*: 3. Melanostoma mellina *L.* ♂. **B. Hymenoptera.** *Apidae*: 4. Bombus pomorum *Pz.* ♂; 5. B. terrester *L.* ♂; 6. Halictus cylindricus *F.* ♂; 7. H. flavipes *F.* ♂.

1540. C. glaucus Baumg.—

VISITORS.—Loew observed the butterfly Melanargia galatea *L.*, skg., in Steiermark ('Beiträge,' p. 49).

1541. C. acanthoides L. (Herm. Müller, 'Fertilisation,' pp. 339–40, 'Weit. Beob.,' III, p. 83, 'Alpenblumen,' p. 417; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Herbstbeob.')—The heads of this species are also bright purple in colour, and more conspicuous than those of C. crispus, for (according to Hermann Müller) the linear lobes of the bells are 7–8 mm. long. As too the nectar-containing bell is somewhat wider, but less deep (2 mm.) than in C. crispus, the number of visitors is greater. In other respects the flower mechanism, including the securing of cross-pollination by insect-visits and the possibility of automatic self-pollination should these fail, entirely agrees with those of C. crispus and Cirsium arvense.

VISITORS.—Herm. Müller gives the following list for Central Germany.—

A. Coleoptera. (*a*) *Chrysomelidae*; 1. Cryptocephalus sericeus *L.* (*b*) *Curculionidae*: 2. Larinus jaceae *F.*; 3. Spermophagus cardui *Stev.*, in very large numbers in the florets. (*c*) *Elateridae*: 4. Corymbites holosericeus *Oliv.* (*d*) *Scarabaeidae*: 5. Trichius fasciatus *L.* **B. Diptera.** (*a*) *Conopidae*: 6. Conops scutellatus

Mg., skg.; 7. Physocephala rufipes *F.*, do. (*b*) *Syrphidae*: 8. Eristalis arbustorum *L.*, skg. **C. Hemiptera.** 9. Anthocoris sp. **D. Hymenoptera.** (*a*) *Apidae*: 10. Bombus agrorum *F.* ☿, skg.; 11. B. lapidarius *L.* ☿, do.; 12. B. pratorum *L.* ♂, do.; 13. B. sylvarum *L.* ☿ and ♀, do.; 14. Cilissa tricincta *K.* ♀, do.; 15. Chelostoma campanularum *L.* ♀ and ♂, skg. and po-dvg.; 16. Dasypoda hirtipes *F.* ♀, skg.; 17. Halictus albipes *F.* ♂, freq., skg.; 18. H. cylindricus *F.* ♂, skg.; 19. H. interruptus *Pz.* ♂, do.; 20. H. leucozonius *Schr.* ♂ and ♀, skg. and po-cltg.; 21. H. longulus *Sm.* ♂ and ♀, skg.; 22. H. lucidulus *Schenck* ♀, do.; 23. H. maculatus *Sm.* ♂ and ♀, do.; 24. H. minutus *K.* ♂, do.; 25. H. nitidiusculus *K.* ♂ and ♀; 26. H. quadricinctus *F.* ♂ and ♀, very common, skg.; 27. H. quadrinotatus *K.* ♂, occasional, skg.; 28. H. rubicundus *Chr.* ♂ and ♀, in large numbers, skg.; 29. H. smeathmanellus *K.* ♀, skg.; 30. Heriades truncorum *L.* ♀ and ♂, skg. and po-cltg.; 31. Megachile centuncularis *L.* ♂, skg.; 32. M. lagopoda *L.* ♀ and ♂, skg. and po-cltg.; 33. M. versicolor *Sm.* ♀, skg.; 34. Osmia aenea *L.* ♂, do.; 35. O. auruleata *Pz.* ♀, skg. and po-cltg.; 36. O. fulviventris *F.* ♀, do.; 37. Prosopis punctulatissima *Sm.* ♀, skg.; 38. Stelis aterrima *Pz.* ♀ and ♂, in large numbers, skg.; 39. S. breviuscula *Nyl.* ♀, skg.; 40. S. phaeoptera *K.* ♀, not infrequent, skg. (*b*) *Sphegidae*: 41. Cerceris variabilis *Schr.* ♀, skg. **E. Lepidoptera.** (*a*) *Noctuidae*: 42. Plusia gamma *L.*, skg. (*b*) *Rhopalocera*: 43. Argynnis aglaja *L.*, skg.; 44. Epinephele janira *L.*, do.; 45. Pieris brassicae *L.*, do. (*c*) *Sphingidae*: 46. Zygaena carniolica *Scop.*, skg.

The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel Botanic Garden), 2 humble-bees (Bombus lapidarius *L.* ♀ and ☿, skg., and B. terrester *L.*, do.) and 2 butterflies (Pieris brassicae *L.*, skg., and Vanessa io *L.*, do.). Herm. Müller (Alps), 4 humble-bees, 3 Lepidoptera, and a beetle. Schmiedeknecht (Tyrol), the bee Osmia confusa *Mor.* (*teste* Morawitz). Schletterer (Tyrol), the two dasygastrid bees Osmia confusa *Mor.*, and Megachile willughbiella *K.* Schiner (Austria), the Muscid Oxyphora miliaria *Schr.*

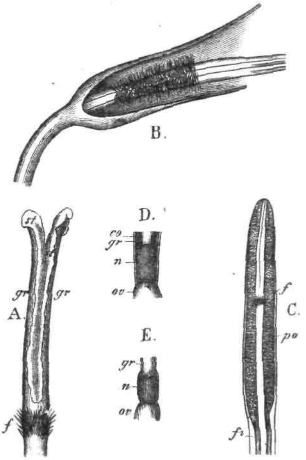


FIG. 206. *Carduus defloratus*, *L.* (after Herm. Müller). *A.* Upper part of the style (× 17). *B.* Lower part of he corolla-tube, cut open (× 7). *C.* Longitudinal section through the anther-cylinder shortly before the opening of the floret (× 7). *D.* Lowest part of the corolla-tube, cut open. *E.* Lowest part of the style (× 7). *co*, corolla-tube; *f*, sweeping-hairs; *fi*, filaments; *gr*, style and its branches; *n*, nectary; *ov*, ovary; *po*, pollen; *st*, stigmas.

1542. C. defloratus L. (Herm. Müller, 'Alpenblumen,' pp. 418–22.)—In this species the heads contain 100–200 purple florets, and are only 20 mm. below, but 25–30 mm. above, where the corollas bend outwards. The tube of the corolla is 7–8 mm. long, and its bell about 5 mm. deep, with 5 linear diverging lobes 6–7 mm. in length. On both sides of the lowest lobe the bell is cleft to a depth of 3 mm., so that insects with a proboscis 3 mm. long can reach the nectar which rises into the bell.

In the first stage of anthesis the florets are covered by an abundance of bluish-coloured pollen; in the second stage the stylar branches diverge somewhat at the tip, and their papillose stigmatic edges swell outwards. The second stage lasts considerably longer than the first. Should insect-visits fail, automatic self-pollination may be effected by the further swelling of the stigmatic margins of the stylar branches, until they touch the pollen that remains clinging to the floret. But autogamy is scarcely likely to take place, for Hermann Müller observed a very large number of insect visitors (not less than 103 species) in Switzerland, i. e. 8 beetles, 10 flies, 31 Hymenoptera, and 54 Lepidoptera.

Visitors.—Loew observed the humble-bee Bombus terrester *L.* ♂, skg. in the Berlin Botanic Garden, and the following in Switzerland ('Beiträge,' p. 58).—

A. Diptera. (*a*) *Bombyliidae*: 1. Argyromoeba sinuata *Fall.*, skg. (*b*) *Empidae*: 2. Empis tessellata *F.* (*c*) *Tabanidae*: 3. Tabanus bromius *L.* **B. Hymenoptera.** *Apidae*: 4. Halictus quadricinctus *F.* ♀; 5. Osmia villosa *Schenck* ♀ and ♂, skg., ♀ also po-cltg. **C. Lepidoptera.** (*a*) *Rhopalocera*: 6. Parnassius delius *Esp.* (*b*) *Sphingidae*: 7. Zygaena exulans *Hchw. et. Rein.*

1543. **C. Personata** Jacq. (=Arctium Personata *L.*). (Herm. Müller, 'Alpenblumen,' pp. 417–18.)—In this species there are about 6 burr-like purple-red heads at the end of the stem, each measuring 30–40 mm. in diameter. Each of the 150–200 florets in a head possesses a corolla-tube 7–9 mm. in length, and a bell (ventricose below) about 3 mm. long. The filaments are highly irritable. In other respects the flower mechanism agrees entirely with that of C. defloratus, the filaments of which, however, are less or not at all irritable.

Visitors.—Herm. Müller noticed 2 beetles, 6 flies, 3 humble-bees, and 6 Lepidoptera.

Loew observed 2 bees in the Berlin Botanic Garden—1. Apis mellifica *L.* ☿, skg.; 2. Osmia fulviventris *Pz.* ♀, po-cltg.

1544. **C. nutans** L. (Sprengel, 'Entd. Geh.,' pp. 370–1; Herm. Müller, 'Fertilisation,' p. 340, 'Weit. Beob.,' III, pp. 83–4; Loew, 'Blütenbiol. Floristik,' p. 390; Kirchner, 'Flora v. Stuttgart,' p. 390.)—Kirchner says that in this species several hundred purple-red florets are aggregated into an odorous head, which presents a surface about 40 mm. in diameter. The corolla-tube of each floret is 10 mm. and the bell 5 mm. long, while the corolla-lobes vary from 5 to 8 mm. in length. In other respects the flower mechanism agrees with that of C. arvense.

Visitors.—Herm. Müller gives the following list for Central Germany.—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*, po-dvg.; 2. Syrphus ribesii *L.*, do. **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.*, freq., skg.; 4. Bombus hortorum *L.* ♂, skg.; 5. B. hypnorum *L.* ☿, do.; 6. B. pratorum *L.* ☿ and ♂, do.; 7. B. sylvarum *L.* ♀ and ♂, do.; 8. Psithyrus vestalis *Fourcr.*, do.; 9. Halictus cylindricus *F.* ♂, do.; 10. H. leucozonius *Schr.* ♀, po-cltg.; 11. H. malachurus *K.* ♀, skg.; 12. H. quadrinotatus *K.* ♂, do. (Thuringia); 13. H. sexcinctus *F.* ♀, skg. and po-dvg.; 14. H. zonulus *Sm.* ♀, skg. (Thuringia). **C. Lepidoptera.** (*a*) *Rhopalocera*: 15. Argynnis aglaja *L.*, in large numbers, skg.; 16. A. paphia *L.*, skg.; 17. Epinephele janira *L.*, do. (Thuringia); 18. Hesperia lineola *O.*, skg. (*b*) *Sphingidae*: 19. Zygaena lonicerae *Esp.*, skg.

The following were recorded by the observers, and for the localities stated.—

Loew (Brandenburg), the bee Megachile lagopoda *L.* ♀, po-cltg. ('Beiträge,' p. 39); (Silesia) Parnopes grandior *Pall.*, skg. (op. cit., p. 31). Schmiedeknecht (Thuringia), 2 parasitic humble-bees—Psithyrus globosus *Ev.* ♂, and P. rupestris *F.* ♂. Alfken (Bremen), 10 bees—1. Bombus arenicola *Ths.* ♂; 2. B. distinguendus *Mor.* ☿; 3. B. lapidarius *L.* ☿; 4. B. ruderatus *F.* ♀, skg.; 5. B. terrester *L.* ♂; 6. Halictus calceatus *Scop.* ♀; 7. Osmia solskyi *Mor.* ♀; 8. Psithyrus barbutellus *K.* ♀ and ♂; 9. P. campestris *Pz.* ♂; 10. P. rupestris *F.* ♂. Schiner (Austria), 3 Muscids—1. Oxyphora miliaria *Schr.*; 2. Urophora solstitialis *L.*; 3. U. stylata *F.* Schletterer (Pola; and for the Tyrol = T.).—**Hymenoptera.** (*a*) *Apidae*: 1. Andrena florea *F.*, po-cltg.; 2. Bombus hypnorum *L.* (T.); 3. B. mesomelas *Gerst.* (T.); 4. B. terrester *L.* (T.); 5. Ceratina nigroaenea *Gerst.*; 6. Halictus levigatus *K.* ♂; 7. H. morbillosus *Krchb.*; 8. H. quadricinctus *F.*; 9. H. scabiosae *Rossi*; 10. Osmia fulviventris *Rossi*; 11. Psithyrus rupestris *F.* (T.). (*b*) *Scoliidae*: 12. Scolia insubrica *Rossi*.

1545. **C. medius** Gouan.—According to MacLeod ('Pyreneënbl.,' pp. 352–4), the diameter of the purple-red heads of this species is 30 mm. in the Pyrenees. The corolla-tube is 10–11 mm. long, and the ventricose nectar-containing bell is 4–5½ mm. deep. Insects with a proboscis 4–5 mm. in length are therefore able to suck the nectar, while beetles, with short-tongued flies and Hymenoptera, may be found devouring the pollen.

Visitors.—MacLeod observed 14 Hymenoptera, 16 Lepidoptera, 6 beetles, 3 Syrphids, and 9 Muscids.

1546. **C. carlinoides** Gouan.—MacLeod states that the purple heads of this species are 25–30 mm. in diameter in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891). The corolla-tube is 7–8 mm. long, and the bell 3–4 mm. deep. As in the last species, most of the visitors are long-tongued insects.

Visitors.—MacLeod observed 14 Hymenoptera, 2 Lepidoptera, a beetle, a Muscid, and an Empid.

1547. **C. pycnocephalus** L.—

Visitors.—Schletterer observed the following at Pola.—

Hymenoptera. (*a*) *Apidae*: 1. Anthidium septemdentatum *Ltr.*; 2. Andrena lucens *Imh.*; 3. Ceratina cucurbitina *Rossi*; 4. Osmia fulviventris *Pz.*; 5. O. spinolae *Schenck*; 6. Prosopis hyalinata *Sm.*, var. subquadrata *F.* (*b*) *Chrysididae*: 7. Holopyga amoenula *Dahlb.* (*c*) *Sphegidae*: 8. Pemphredon unicolor *F.*; 9. Tachytes obsoleta *Rossi*.

470. Onopordon L.

Florets, hermaphrodite, tubular. Stylar branches non-divergent; rows of stigmatic papillae on their outer margins; at their base a ring of moderately short sweeping-hairs directed obliquely upwards.

1548. **O. acanthium** L. (Herm. Müller, 'Fertilisation,' pp. 344–5, 'Weit. Beob.,' III, p. 81, 'Alpenblumen,' p. 417; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, p. 252; Knuth, 'Blütenbiol. Herbstbeob.,' 'Blütenbiol. biol. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen.')—The bright purple florets of this species, according to Hermann Müller, possess a corolla-tube 10–12 mm. in length, and a bell 3–4 mm. deep, with 5 linear non-divergent lobes 6–8 mm. long. The nectar ascends as far as the bell. In the first stage of anthesis the pollen which has

been swept out covers the florets; in the second stage the stigma projects 5–7 mm beyond the lobes of the corolla, and the stigmatic papillae are turned prominently outwards. As regards the irritability of the filaments in this species, Kerner says that as in other Compositae the pollen is protected from rain and dew by the anther-cylinder, but by the retraction of this the upper end of the style and the pollen covering it are exposed.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Central Germany.—

A. Coleoptera. *Coccinellidae*: 1. Coccinella mutabilis *Scrib.*, vainly seeking for nectar (H. M.). **B. Hemiptera.** 2. Capsus, 2 different sp., skg. (H. M.); 3. Lygaeus equestris *L.*, skg. (H. M., Thuringia). **C. Hymenoptera.** (*a*) *Apidae*: 4. Andrena schrankella *Nyl.* ♀ (H. M.); 5. Bombus lapidarius *L.* ☿, skg. (H. M.); 6. Psithyrus rupestris *F.* ♀, do. (H. M.); 7. Bombus terrester *L.* ♀, do. (H. M.); 8. Coelioxys conoidea *Ill.* ♀, do. (H. M.); 9. Halictus cylindricus *F.* ♀ (Budd.); 10. H. leucozonius *Schr.* ♀, skg. (H. M., Thuringia); 11. H. maculatus *Sm.*, po-cltg. (H. M., Thuringia); 12. H. quadricinctus *F.* ♀, skg. (Budd.); 13. H. quadristrigatus *Ltr.* ♀, do. (H. M.); 14. H. sexcinctus *F.* ♂ (Budd.); 15. H. tetrazonius *Klg.* ♀ (Budd.); 16. Megachile lagopoda *L.* ♀ and ♂, po-cltg. and skg. (H. M., Budd.); 17. M. ligniseca *K.* ♀, do. (Budd.); 18. Osmia aurulenta *Pz.* ♀, do. (H. M., Thuringia); 19. O. fulviventris *Pz.* ♀, freq., skg. and po-cltg. (Budd.); 20. Saropoda bimaculata *Pz.* ♀, skg. (H. M.); 21. Stelis aterrima *Pz.* ♀ and ♂, do. (H. M., Budd.); 22. S. phaeoptera *K.* ♀, do. (Budd.). (*b*) *Sphegidae*: 23. Psammophila affinis *K.* ♀, skg. (H. M.). **D. Lepidoptera.** (*a*) *Rhopalocera*: all skg.: 24. Hesperia sylvanus *Esp.* (H. M., Thuringia); 25. Melanargia galatea *L.* (H. M.); 26. Vanessa cardui *L.* (H. M., Thuringia); 27. V. urticae *L.* (H. M.). (*b*) *Sphingidae*: 28. Macroglossa stellatarum *L.*, skg. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), a humble-bee. Knuth (Kiel Botanic Garden), 4 skg. humble-bees (1. Bombus agrorum *F.*; 2. B. hortorum *L.*; 3. B. lapidarius *L.*; 4. B. terrester *L.*), 4 skg. butterflies (1. Pieris napi *L.*; 2. Vanessa atalanta *L.*; 3. V. io *L.*; 4. V. urticae *L.*), and a Muscid (Calliphora erythrocephala *Mg.*): (Rügen), a butterfly (Pieris sp.). Gerstäcker (Berlin), the bee Osmia fulviventris *Pz.* ♀. Schmiedeknecht (Thuringia), the bee Osmia solskyi *Mor.* ♀. Friese (Hungary), the bee Eucera nigrifacies *Lep.* Schiner (Austria), the Muscid Tephritis postica *Loew.* von Dalla Torre (Tyrol), 5 bees,—1. Bombus hypnorum *L.* ♂; 2. B. muscorum *F.* ♂; 3. Andrena cetii *Schr.* ♀; 4. Halictus sexcinctus *Fbr.* ♀; 5. Stelis phaeoptera *K.* ♀. Schletterer (Tyrol), 4 bees,—1. Andrena marginata *F.*; 2. Bombus hypnorum *L.*; 3. Halictus sexcinctus *F.*; 4. Stelis phaeoptera *K.*

471. **Lappa** Rupp.

Florets tubular, hermaphrodite. Stylar branches very short, beset internally with stigmatic papillae, externally with short pointed sweeping-hairs directed obliquely upwards, extending below the bifurcation, and ending beneath in a ring of longer sweeping-hairs.

1549. L. minor DC. (Hildebrand, 'Ü. d. Geschlechtsverhält b. d. Compositen,' p. 46, Taf. V, Fig. 32; Herm. Müller, 'Fertilisation,' p. 338, 'Weit. Beob.,' III, p. 84; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 161.)—In this species the heads are rather small, usually only about the size of a hazel-nut, but they are rendered more conspicuous by the reddish colour of the inner involucral bracts. The corolla is coloured purple

above, and Herm. Müller states that its bell is 3 mm. long. The lobes of the corolla are erect, triangular, and only 1 mm. in length. During the first stage of anthesis the pollen is discharged from the anther-cylinder; in the second stage the style projects from its tip to 1–2 mm. below the ring of longer sweeping-hairs, and its branches diverge completely. These are beset with stigmatic papillae on their inner surface.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands and Kiel), Apis and 2 Lepidoptera (Pieris sp., and Plusia gamma *L.*), skg. Herm. Müller (Westphalia), 2 bees (Bombus agrorum *F.* ☿, skg.; and Halictus longulus *Sm.* ☿, do.). Buddeberg (Nassau), 2 bees (Halictus cylindricus *F.* ♀ and ♂, skg., and Stelis aterrima *Pz.* ♀ and ♂, do.), and a fossorial wasp (Ammophila sabulosa *L.* ♀, skg.). Alfken (Bremen), the humble-bee Bombus proteus *Gerst.* ♂. MacLeod (Pyrenees), a humble-bee (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 359).

1550. **L. tomentosa** Lam.—

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller, a Noctuid (Plusia gamma *L.*, skg.) and 5 bees—1. Apis, skg. and po-cltg.; 2. Bombus agrorum *F.* ☿ and ♂, skg.; 3. B. sylvarum *L.* ☿, do.; 4. Psithyrus campestris *Pz.* ♂, do.; 5. Megachile centuncularis *L.* ♀, do. ('Fertilisation,' p. 338). Loew (Berlin Botanic Garden), the last-named bee: (Switzerland), the Muscid Trypeta tussilaginis *F.* ('Beiträge,' p. 59). H. de Vries (Netherlands), 2 humble-bees (Bombus agrorum *F.* ☿, and B. subterraneus *L.* ♂) and a parasitic humble-bee (Psithyrus campestris *Pz.* ♂) (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875).

1551. **L. major** Gaertn.—

VISITORS.—Herm. Müller (Alps) noticed Apis, 3 humble-bees, and 3 Lepidoptera ('Alpenblumen,' p. 426).

472. Carlina L.

Florets hermaphrodite. The whitish inner bracts of the involucre take the place of ray-florets, but, besides adding to the conspicuousness of the head, they serve as a protection, closing over the florets in wet weather. The style bears numerous sweeping-hairs on the outer side of its tip, which is shaped like an inverted club, and these hairs extend below the cleft. The stylar branches are very short and remain almost closed, but allow a row of stigmatic papillae to protrude along their outer edges where they touch. The outer involucral bracts are spinose, forming an effective protection against animals that might creep up to the flowers.

1552. **C. acaulis** L. (Herm. Müller, 'Alpenblumen,' pp. 414–15; Knuth, 'Blütenbiol. Herbstbeob.,' 'Bloemenbiol. Bijdragen.')—In this species several hundred similar florets make up the inconspicuous head, which lies upon the ground, and is 20–40 mm. in diameter. The 60–80 inner involucral bracts are dry, rigid, band-shaped, and of a glistening white colour. They measure 35–40 mm. in length and 2½–3 mm. in breadth, and give to the head the appearance of a shining star 75–80 mm. in diameter. The corolla-tube of each floret is 4–5 mm. long, and the bell 5–6 mm. The short, blunt stylar branches are scarcely 1 mm. in length, and bear a circlet of

long sweeping-hairs on the outside, below the short ones that extend below the cleft. Kerner says that the heads open at Innsbruck between 7 and 8 a.m., closing again between 6 and 7 p.m.

VISITORS.—Herm. Müller gives the following list for Thuringia ('Fertilisation,' p. 338).—

A. Coleoptera. *Curculionidae*: 1. Larinus senilis *F.*, larvae and pupae are to be found in the common receptacle, the perfect beetles on the flowering capitula and other parts of the plant. **B. Hymenoptera.** *Apidae*: 2. Bombus agrorum *F.* ♂, very numerous, skg.; 3. B. confusus *Schenck* ♂, do.; 4. B. lapidarius *L.* ♂, do.; 5. B. muscorum *F.* ♂, do.; 6. B. sylvarum *L.* ♂, do.; 7. B. terrester *L.* ♂, do.; species of Halictus, especially 8. Halictus cylindricus *F.* ♂; and 9. H. quadricinctus *F.* ♂; 10. Psithyrus rupestris *L.* ♂.

The following were recorded by the observers, and for the localities stated.—

Knuth (Bernese Oberland), the humble-bee Bombus lapidarius *L.*, skg.; (Kiel Botanic Garden), 3 bees (1. Bombus hortorum *L.*; 2. B. terrester *L.*; 3. Apis), a butterfly (Vanessa io *L.*), and a hover-fly (Eristalis arbustorum *L.*); all skg. Herm. Müller (Alps), 3 humble-bees and 2 Lepidoptera. Redtenbacher (Austria), the weevil Larinus senilis *F.* Hoffer (Steiermark), the humble-bee Bombus pomorum *Pz.*, *var.* elegans *Seidl.* (=B. mesomelas *Gerst.*). Schmiedeknecht (Thuringia), 2 bees (Bombus pomorum *Pz.*, and Psithyrus rupestris *F.*). MacLeod (Pyrenees), a humble-bee, an ant, and a Muscid (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 358).

1553. **C. acanthifolia** All.—The yellow heads of this species are rendered more conspicuous by the golden-yellow involucre.

VISITORS.—MacLeod observed a humble-bee in the Pyrenees (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 358–9).

1554. **C. vulgaris** L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 161, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 236; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 402; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In the island of Sylt this species usually bears only one head (rarely 2–5), 40 mm. in diameter. This consists of several hundred florets, and is surrounded by several series of strong thorny protective involucral bracts, within which is a circlet of straw-coloured bracts 20 mm. long and $1\frac{1}{2}$–2 mm. broad. These are membranous and not prickly. They play the part of a ray so well that the heads, which but for them would be inconspicuous, are visible at a great distance. In dull weather, and when it is dark, these bracts bend inwards and upwards, so as to form a protective cover. Beneath this again is a second conical roof, formed by the bristle-like chaffy bracteoles, which project several mm. beyond the florets.

The pollen, as in all Compositae, is shed into the anther-cylinder, while the florets are still closed, and is brushed out by the stiff sweeping-hairs, which are directed obliquely upwards. When the anther-cylinder is empty, the laterally placed stigmatic papillae make their appearance.

Warnstorf adds the following particulars.—The limb of the corolla is dark-violet at the time of anthesis, and the edges of its teeth are beset with simple and irregularly branched short hairs, adapted to hold fast the pollen as it falls. The florets are about 10–11 mm. long, and the anther-cylinder projects for as much as 3 mm. By contraction of the filaments the latter is subsequently completely withdrawn into the corolla, so that the dirty-yellow pollen-grains are completely

exposed. The stylar branches are short, covered externally with sweeping-hairs (which are somewhat longer beneath the cleft) and beset with stigmatic papillae internally. At a late stage they diverge at an acute angle. The inner straw-coloured linear involucral bracts here play the part of the ray-florets of other Compositae, and periodically bring about opening and closing, so that the stigmas of the older florets are brought into contact with the pollen of neighbouring younger ones. Geitonogamy is thus provided for, should insect-visits fail. The pollen-grains are roundish, with low spinose tubercles, and are about 50 μ in diameter.

Kerner says that the heads open about 7–8 a.m., closing again 12 hours later.

VISITORS.—Herm. Müller (H. M.) ('Fertilisation,' p. 338, 'Weit. Beob.,' III, p. 79) and Buddeberg (Budd.) give the following list for Thuringia and Nassau.—

Hymenoptera. All skg. (*a*) *Apidae*: 1. Bombus lapidarius *L.* ♂ (H. M.); 2. B. terrester *L.* ♂ (H. M.); 3. B. tristis *Seidl.* ♂ (H. M., Schwiebus); 4. Coelioxys acuminata *Nyl.* ♀ (H. M.); 5. C. quadridentata *L.* ♀ (H. M.); 6. Halictus cylindricus *F.* ♂, very common (H. M.); 7. H. quadricinctus *F.* ♂ (H. M., Budd.), freq.; 8. Megachile circumcincta *K.* ♀ (H. M.); 9. M. lagopoda *L.* ♂, once (H. M.). (*b*) *Sphegidae*: 10. Ceropales maculatus *F.* ♀ (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth, 3 sucking humble-bees (1. Bombus derhamellus *K.*; 2. B. lapidarius *L.*; 3. B. terrester *L.*), a po-dvg. hover-fly (Syrphus balteatus *Deg.* ♂), and 2 po-dvg. Muscids (Olivieria lateralis *F.*, and Anthomyia sp. ♀). Schletterer (Tyrol), the humble-bee Bombus derhamellus *K.* MacLeod (Pyrenees), 3 humble-bees and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 358).

473. Saussurea DC.

Florets hermaphrodite. Outer surface of the stylar branches completely covered with long pointed sweeping-hairs, which are longest below: inner surface beset with stigmatic papillae. These branches diverge and roll back.

1555. **S. alpina** DC. (Herm. Müller, 'Alpenblumen,' pp. 413–14.)—In this species each head is made up of 11–17 florets, with a white corolla-tube 7–8 mm. and a violet bell 2 mm. in length. From 5–9 such heads are closely aggregated. The florets are protandrous, and smell like violets or vanilla.

VISITORS.—Hermann Müller thinks these are probably po-dvg. flies, together with po-cltg. and nect-skg. bees; but he only saw a single hover-fly. Lindman observed flies, a saw-fly, and a humble-bee on the Dovrefjeld.

1556. **S. albescens** Hook. et Thoms.—

VISITORS.—Loew observed 3 bees (1. Apis mellifica *L.* ☿, skg.; 2. Bombus hortorum *L.* ♂, do.; 3. Halictus nitidiusculus *K.* ♂, do.) and an undetermined Chalcidid in the Berlin Botanic Garden.

474. Jurinea Cass.

1557. **J. mollis** Reichb. (v. Wettstein, 'Compos. d. öst-ungar. Flora.')—In this species the stomata of the young unopened heads secrete nectar which entices ants—usually Camponotus sylvaticus *Oliv.*, var. aethiops *Latz.*, more rarely Aphenogaster

structor *Latz.*, at Vienna and Budapest. The ants keep off injurious insects. The secretion ceases at the beginning of anthesis.

1558. **J. alata.**—According to Hildebrand ('Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 58–9), the style is similar in structure to that of Centaurea montana.

Visitors.—Loew observed the po-cltg. bee Osmia fulviventris *Pz.* ♀ in the Berlin Botanic Garden.

475. Alfredia Cass.

1559. **A. cernua** Cass.—

Visitors.—Loew observed the humble-bee Bombus terrester *L.* ♀, po-cltg., in the Berlin Botanic Garden.

476. Rhaponticum Hall.

1560. **R. pulchrum** Fisch. et Mey. (=Centaurea pulchra *DC.*).—

Visitors.—Loew observed 3 bees (1. Dasypoda hirtipes *F.* ♂, skg.; 2. Osmia fulviventris *Pz.* ♀, po-cltg.; 3. Stelis aterrima *Pz.* ♀, skg.) and a wasp (Odynerus parietum *L.*) in the Berlin Botanic Garden.

477. Serratula Dill.

Florets hermaphrodite or dioecious.

1561. **S. tinctoria** L. (Kirchner, 'Flora v. Stuttgart,' p. 727; Herm. Müller, '*Fertilisation*,' pp. 345–6; Knuth, 'Blütenbiol. Herbstbeob.')—This species is gyno-dioecious, and bears purple-red florets. Kirchner says there are transition-forms between the female and hermaphrodite ones.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Thuringia), a humble-bee (Bombus agrorum *F.* ♀ and ♂, skg.) and a butterfly (Colias hyale *L.*, freq., skg.). Knuth (Kiel Botanic Garden), 6 hover-flies, po-dvg. and skg. (1. Eristalis horticola *Deg.*; 2. E. pertinax *Scop.*; 3. Platycheirus sp.; 4. Syritta pipiens *L.*; 5. Syrphus ribesii *L.*; 6. S. umbellatarum *L.*), and 2 butterflies, skg. (Pieris sp., and Vanessa io *L.*). Schiner (Austria), the Muscid Trypeta ruficauda *F.*

1562. **S. quinquefolia** Bieb.—

Visitors.—Loew observed 2 humble-bees (Bombus agrorum *F.* ♂, and B. terrester *L.* ♀, skg.) in the Berlin Botanic Garden.

1563. **S. lycopifolia** Vill., and 1564. **S. centauroides** Bieb. (=S. radiata *Bieb.*). (Von Wettstein, 'Compos. d. öst.-ungar. Flora.')—Wettstein says that in these species nectar is discharged in abundance from the stomata on the involucral bracts of the young unopened heads, serving to attract ants that keep injurious insects from the buds. (*Cf.* Jurinea mollis.)

Visitors.—Wettstein observed 4 ants on S. lycopifolia (1. Formica exsecta *Nyl.*; 2. F. rufibarbis *F.*; 3. Lasius niger *L.*; 4. Myrmica lobicornis *Nyl.*), and one (Lasius alienus *Först.*) on S. centauroides.

478. Cnicus L.

Style of the hermaphrodite florets very similar to that of Centaurea (montana).

1565. C. benedictus L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 57–8, Taf. V, Fig. 31.)—Although the anthers appear normal in this species, the first florets produce no pollen. The neuter ray-florets are so small as to be hardly visible beside the disk-florets.

479. Centaurea L.

Ray-florets neuter, tubular, radiating. Disk-florets hermaphrodite. Filaments very irritable. Below the short broad stylar branches a ring of sweeping-hairs directed obliquely upwards; above this short hairs on the style; stigmatic papillae on the inner surfaces of the branches. Kerner states that the pollen is concealed in the anther-cylinder until insects visit the florets, being thus protected from rain and dew. When the proboscis of a nectar-seeking insect stimulates the filaments, they contract so that the crumbling pollen is carried off by the visitor as soon as it is swept out. After removal of the pollen, only cross-fertilization is possible for a short time; the stylar branches then roll back in such a way that the stigmatic papillae touch the pollen still clinging to the sweeping-hairs, thus effecting self-pollination. I have not myself observed this rolling back of the branches. In some species—C. alpina (Wettstein); C. montana, in the Apennines (Delpino), but not at Vienna (Wettstein)—nectar is secreted by the involucral bracts of the bud, as in Serratula lycopifolia, S. centauroides, and Jurinea mollis. Wettstein observed the ant Camponotus sylvaticus *Oliv.*, var. aethiops *Latz.*, on C. alpina in Istria.

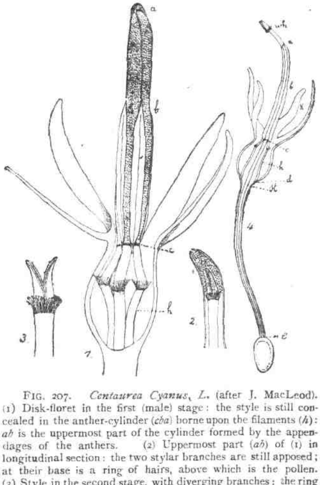


FIG. 207. *Centaurea Cyanus, L.* (after J. MacLeod). (1) Disk-floret in the first (male) stage: the style is still concealed in the anther-cylinder (*cba*) borne upon the filaments (*h*): *ab* is the uppermost part of the cylinder formed by the appendages of the anthers. (2) Uppermost part (*ab*) of (1) in longitudinal section: the two stylar branches are still apposed; at their base is a ring of hairs, above which is the pollen. (3) Style in the second stage, with diverging branches; the ring of hairs is laden with pollen-grains, a few of which adhere to the papillose inner surfaces of the branches. (4) Disk-floret in the second (female) stage, half schematic: the style protrudes from the tip of the anther-cylinder. *ab*, appendages of the anthers; *bc*, anthers; *de*, corolla-tube (the nectary (not figured) is situated at *e*); *h*, filaments; *k*, lobes of the corolla; *st*, style; *wh*, ring of sweeping-hairs.

1566. C. Jacea L. (Herm. Müller, 'Fertilisation,' pp. 346–9, 'Weit. Beob.,' III, pp. 79–80, 'Alpenblumen,' p. 415; Loew, 'Blütenbiol. Floristik,' pp. 390, 393, 397; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 401–2; Knuth, 'Blütenbiol. Herbstbeob.,' 'Bloemenbiol. Bijdragen.')—This species is trioecious. The

florets are usually of a bright purple colour, and, according to Hermann Müller from 60 to over 100 are found in one head. The capitulum is compressed below to a diameter of 8–10 mm., but spreads out above to form a surface 20–30 mm. across. The sterile ray-florets only serve to render the heads conspicuous, and are modified into large outwardly directed funnels. The disk-florets are hermaphrodite; the corolla-tube is 7–10 mm. and the bell 3–4½ mm. long. There are 5 linear corolla-lobes, 5 mm. in length. The filaments are hairy and irritable; they bend when touched by the proboscis of an insect visitor, pulling down the anther-cylinder. The result is that the annular stylar brush sweeps out the pollen contained in the cylinder. At a later stage the style grows out from this, and the papillose inner surfaces of the stylar branches of the style separate to some extent. Automatic self-pollination is therefore excluded, according to Hermann Müller. (*Vide supra* for Kerner's view.) But self-pollination may be brought about by insects when the stigmatic papillae are exposed, if the pollen has not been completely removed. When visitors are numerous, however, no pollen is left on the head during the second stage of anthesis, so that crossing is necessarily effected. Warnstorf describes the pollen-grains as white in colour, ellipsoidal, furrowed, and covered with low spinose tubercles, about 56 μ long and 30 μ broad.

Hermann Müller also observed plants bearing male and female heads with enlarged ray-florets, while MacLeod (in Belgium) saw some rayless female heads besides the hermaphrodite ones, with neuter ray-florets. The male heads are of a paler colour: their ray-florets are greatly enlarged; the nectary is vestigial, and the stylar branches are permanently apposed. The florets of the female heads are darker and smaller, with shrunken anthers devoid of pollen.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Central Germany.—

A. Diptera. (*a*) *Conopidae*: 1. Conops flavipes *L.*, skg. (H. M.); 2. Physocephala vittata *F.*, do. (H. M.); 3. Sicus ferrugineus *L.*, do. (Budd.). (*b*) *Empidae*: 4. Empis livida *L.*, skg. (H. M., Budd.); 5. E. rustica *F.*, do. (H. M.). (*c*) *Syrphidae*: 6. Eristalis intricarius *L.*, skg. (H. M.); 7. E. tenax *L.*, po-dvg., and inserting its long proboscis into the bells of the individual florets (H. M.); 8. Helophilus pendulus *L.*, skg. (H. M.); 9. Rhingia rostrata *L.*, do. (H. M.); 10. Syrphus balteatus *Deg.*, po-dvg. (Budd.). **B. Hymenoptera.** (*a*) *Apidae*: 11. Anthidium strigatum *Pz.*, po-cltg. (H. M., Thuringia); 12. Andrena pilipes *F.* ♀, po-cltg. (H. M.); 13. Apis mellifica *L.* ☿, freq., skg. and po-cltg.; 14. Bombus agrorum *F.* ☿, skg. (H. M.); 15. B. lapidarius *L.* ☿, do. (H. M.); 16. B. pratorum *L.* ♂, do. (H. M.); 17. B. sylvarum *L.* ♀ and ☿, do. (H. M.); 18. Dasypoda hirtipes *F.* ♂, in large numbers, skg. (H. M.); 19. Halictus albipes *F.* ♂, skg. (H. M.); 20. H. cylindricus *F.* ♀ and ♂, very common, skg. and po-cltg. (H. M.); 21. H. interruptus *Pz.* ♂, skg. (H. M.); 22. H. leucozonius *Schr.* ♀ and ♂, skg. and po-cltg. (H. M.); 23. H. longulus *Sm.* ♀ and ♂ (H. M.); 24. H. lucidulus *Schenck* ♀, skg. and po-cltg. (H. M.); 25. H. maculatus *Sm.* ♀ and ♂, do. (H. M.); 26. H. malachurus *K.* ♀, do. (Budd.); 27. H. minutus *K.* ♂, skg. (H. M.); 28. H. nitidiusculus *K.* ♂ and ♀, po-cltg. and skg. (H. M.); 29. H. quadricinctus *F.* ♀ and ♂, freq., skg. and po-cltg. (H. M., Budd.); 30. H. rubicundus *Chr.* ♀ and ♂, skg. and po-cltg. (H. M.); 31. H. sexcinctus *F.* ♀, skg. (Budd.); 32. H. smeathmanellus *K.* ♀, skg. and po-cltg. (H. M.); 33. H. tetrazonius *Klg.* ♀ and ♂, skg. (Budd.); 34. H. villosulus *K.* ♀, skg. and po-cltg. (Budd.); 35. H. zonulus *Sm.* ♂, skg. (H. M.); 36. Megachile centuncularis *L.* ♀ and ♂, po-cltg. and skg. (H. M., Budd.); 37. M. lagopoda *L.* ♀, po-cltg. (H. M., Thuringia); 38. Osmia

spinulosa *K.* ♀, po-dvg. (H. M., Thuringia); 39. Psithyrus barbutellus *K.* ♂, skg. (H. M.); 40. P. campestris *Pz.* ♂, do. (H. M.); 41. P. rupestris *F.* ♀ and ♂, do. (H. M.); 42. P. quadricolor *Lep.* ♂, do. (H. M.); 43. Saropoda bimaculata *L.* ♂, do. (H. M., Liebenau near Schwiebus). (*b*) *Sphegidae*: 44. Ammophila sabulosa *L.* ♀, skg. (H. M.). (*c*) *Vespidae*: 45. Pollistes gallica *L.* (H. M., Thuringia). **C. Lepidoptera.** (*a*) *Noctuidae*: 46. Plusia gamma *L.* (H. M.) (*b*) *Rhopalocera*: 47. Coenonympha pamphilus *L.* (H. M.); 48. Colias hyale *L.* (H. M.); 49. Epinephele janira *L.* (H. M.); 50. Hesperia thaumas *Hfn.* (H. M.); 51. Lycaena coridon *Scop.*, skg. (H. M., Thuringia); 52. L. sp. (H. M.); 53. Melanargia galatea *L.*, in large numbers, skg. (H. M.); 54. Pararge megaera *L.* (H. M.); 55. Pieris brassicae *L.* (H. M.); 56. P. napi *L.* (H. M.); 57. Polyommatus phlaeas *L.* (H. M.). (*c*) *Sphingidae*: 58. Zygaena carniolica *Scop.* (H. M., Thuringia); 59. Z. lonicerae *Esp.* (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth (Glücksburg), the butterfly Pieris napi *L.*, very freq., skg.: (Kiel), all skg., 3 bees (1. Apis mellifica *L.*; 2. Bombus lapidarius *L.*; 3. Psithyrus rupestris *F.*), 4 hover-flies (1. Eristalis nemorum *L.*; 2. Helophilus hybridus *Loew*; 3. H. pendulus *L.*; 4. Rhingia campestris *L.*), and 4 Lepidoptera (1. Lycaena sp.; 2. Pieris sp.; 3. Plusia gamma *L.*; 4. Vanessa io *L.*). Herm. Müller (Alps), 3 bees and 3 Lepidoptera. Rössler (Wiesbaden), the moth Grapholitha hohenwarthiana *Tr.*, and the hawk-moth Zygaena meliloti *Esp.* Friese (Thuringia), the bee Halictus sexcinctus *F.* Loew (Brandenburg), the hover-fly Eristalis sepulcralis *L.* ('Beiträge,' p. 39): (Switzerland), the bee Bombus pascuorum *Scop.* ☿, po-cltg., and the hawk-moth Zygaena carniolica *Scop.* (op. cit., p. 58): (Steiermark), 2 bees, po-cltg.—Halictus zonulus *Sm.* ♀, and Megachile melanopyga *Costa* ♀ (op. cit., p. 49). Schletterer (Tyrol), 3 bees—1. Andrena lucens *Imh.*; 2. Bombus pascuorum *Scop.*; 3. Halictus albipes *F.* von Dalla Torre (Tyrol), the ruby-wasp Chrysis analis *Spin.* Hoffer (Steiermark), the parasitic humble-bee Psithyrus barbutellus *K.* ♂. MacLeod (Flanders), 7 long-tongued bees, 5 short-tongued bees, 6 hover-flies, a Muscid, an Empid, and 13 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 401–2). H. de Vries (Netherlands), 2 bees (Megachile argentata *F.* ♀, and M. spinulosa *K.* ♀) and 2 humble-bees (Bombus subterraneus *L.* ♂, and B. terrester *L.* ♂ and ☿) (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875).

1567. C. nigra L.—The florets of this species are bluish-red in colour, and Kirchner ('Beiträge,' p. 70) states that their mechanism agrees with that of C. Jacea. As, however, enlarged ray-florets are never present, the top of the head is only about 25 mm. broad. Each head contains over 100 florets, with a corolla-tube 10 mm. and a bell 4–5 mm. long, the 5 corolla-lobes being of the same length.

Visitors.—Willis observed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. (*a*) *Nitidulidae*: 1. Meligethes viridescens *F.*, very common, po-dvg. (*b*) *Scarabaeidae*: 2. Crepidodera ferruginea *Scop.* **B. Diptera.** (*a*) *Muscidae*: 3. Anthomyia radicum *L.*, po-dvg.; 4. A. sp., freq.; 5. Hylemyia strigosa *F.*, skg.; 6. Trichophthicus cunctans *Mg.*, do. (*b*) *Syrphidae*: 7. Eristalis aeneus *Scop.*, freq., skg.; 8. E. pertinax *Scop.*, po-dvg.; 9. E. tenax *L.*, skg.; 10. Platycheirus albimanus *Mg.*, po-dvg.; 11. P. manicatus *Mg.*, do.; 12. Rhingia rostrata *L.*, freq., skg. and po-dvg.; 13. Sphaerophoria scripta *L.*, skg.; 14. Syrphus balteatus *Deg.*, freq., po-dvg. **C. Hemiptera.** 15. Anthocoris sp.; 16. Calocoris bipunctatus *F.*; 17. C. fulvomaculatus *Deg.* **D. Hymenoptera.** *Apidae*: all skg.: 18. Anthidium manicatum *L.*; 19. Apis mellifica *L.*; 20. Bombus agrorum *F.*; 21. B. hortorum *L.*, freq.; 22. B. lapidarius *L.*; 23. B. pratorum *L.*; 24. B. scrimshiranus *K.*, freq.; 25. B. terrester *L.* **E. Lepidoptera.** (*a*) *Microlepidoptera*: 26. Crambus sp. (*b*) *Rhopalocera*: all skg.: 27. Argynnis aglaia *L.*; 28. A. sp.; 29. Epinephele janira *L.*;

30. Pieris napi *L.*, freq.; 31. P. rapae *L.*; 32. Polyommatus phlaeas *L.*, freq.; 33. Vanessa urticae *L.*

The following were recorded by the observers, and for the localities stated.—

Kirchner, humble-bees and a hover-fly (Eristalis tenax *L.*). Heinsius (Holland), a Conopid (Sicus ferrugineus *L.* ♂), 3 bees (1. Bombus agrorum *F.* ♂; 2. Coelioxys conica *L.* ♀; 3. Megachile centuncularis *L.* ♀), and a butterfly (Pieris brassicae *L.* ♂). MacLeod (Pyrenees), 12 Hymenoptera, 18 Lepidoptera, a beetle, and 6 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 356–7). Scott-Elliot (Dumfriesshire), Apis, 7 humble-bees, another long-tongued bee, 5 hover-flies, 3 Muscids, and 5 Lepidoptera ('Flora of Dumfriesshire,' p. 101). E. D. Marquard (Cornwall), the bee Andrena denticulata *K.* Saunders (England), the bee Rophites quinquespinosus *Spin.*

1568. C. montana L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 50–6, Taf. V, Figs. 1–23.)—In this species the funnel-shaped ray-florets are neuter, while the disk-florets are hermaphrodite. Hildebrand says that the longer sweeping-hairs on the style of the latter are not at the same level, but form an arch beneath the stylar branches. As the style grows up it sweeps the pollen before it, first into the empty cone formed by the teeth of the anthers, then out of the apex of this cone. When an insect visits the florets, the filaments contract when touched by its proboscis, so that still larger masses of pollen protrude, and adhere to the ventral surface of the visitor. The style now protrudes, and the papillose inner surfaces of its branches become exposed. With reference to the secretion of nectar by the involucral bracts, *vide* p. 661.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel Botanic Garden), the humble-bee Bombus hortorum *L.*, skg.: (Iserlohn, in Westphalia), the humble-bee B. lapidarius *L.* ♀, skg. ('Bloemenbiol. Bijdragen'). Schenck (Nassau), 4 bees (1. Coelioxys quadridentata *L.*; 2. Megachile centuncularis *L.*; 3. M. ericetorum *Lep.*; 4. Stelis phaeoptera *K.*). Schletterer and von Dalla Torre (Tyrol), the humble-bee Bombus pratorum *L.* Loew (Berlin Botanic Garden), 2 bees (Apis mellifica *L.* ☿, skg., and Osmia fulviventris *Pz.* ♂, do.).

1569. C. axillaris Willd.—Kirchner ('Beiträge,' p. 71) had an opportunity of examining the flower mechanism of this species on the Simplon, and found it agreed with that of C. montana. The 9–12 neuter ray-florets possess such greatly enlarged corollas that they project 25–35 mm. from the involucre. The corolla-tubes of the disk-florets are 9 mm., the bells 3 mm., and the corolla-lobes 7 mm. in length. The anther-cylinder is 7 mm. long, and projects from the mouth of the floret. The style grows 4 mm. beyond this, and in the second stage of anthesis its branches become recurved.

VISITORS.—Kirchner observed humble-bees; and Loew saw the honey-bee in the Berlin Botanic Garden.

1570. C. Phrygia L.—

VISITORS.—Hermann Müller noticed 2 Lepidoptera in the Alps ('Alpenblumen,' p. 415); and Loew saw the parasitic humble-bee Psithyrus vestalis *Fourcr.* ♂, skg., in the Berlin Botanic Garden.

1571. C. Mureti Jord. (=C. maculosa *auct. pro parte*, and C. caerulescens *Willd.*).—

VISITORS.—Herm. Müller saw a humble-bee and 3 Lepidoptera in the Alps ('Alpenblumen,' p. 415).

1572. **C. Cyanus** L. (Sprengel, 'Entd. Geh.,' pp. 371–3; Herm. Müller, 'Fertilisation,' pp. 350–1, 'Weit. Beob.,' III, pp. 80–1; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 96, 161; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 398–401.)—In this species the ray-florets are usually 8 in number, and Ludvig says that they only serve to attract insects. They are sterile, and modified into large outwardly directed funnels, so as to increase the diameter of the blue surface of the head from 2–5 cm., rendering it conspicuous from all sides. (*Cf.* Plateau's observations, Vol. I, p. 209.) Hermann Müller describes the disk-florets as having a corolla-tube 5–6 mm. in length, which expands into a bell only 3 mm. deep, with 5 linear lobes: nectar ascends to the base of this bell. The disk-florets are not very numerous; they do not form a flat surface, but the anther-cylinders project at intervals. The filaments are highly irritable. (*Cf.* Fig. 207, p. 661.)

VISITORS.—Herm. Müller gives the following list for Westphalia and Thuringia.—

A. Diptera. (*a*) *Empidae*: 1. Empis livida *L.*, freq., skg. (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.*, po-dvg.; 3. Helophilus pendulus *L.*, do.; 4. Melithreptus scriptus *L.*, do.; 5. Rhingia rostrata *L.*, skg. **B. Hymenoptera.** (*a*) *Apidae*: 6. Apis mellifica *L.* ☿, freq., skg. and po-cltg.; 7. Bombus lapidarius *L.* ☿, skg.; 8. B. sylvarum *L.* ☿, do.; 9. Halictus tetrazonius *Klg.* ♀, do.; 10. Megachile maritima *K.* ♂, do.; 11. Saropoda bimaculata *Pz.* ♀, persistently skg. and po-cltg.; 12. Stelis breviuscula *Nyl.* ♀, skg. (*b*) *Sphegidae*: 13. Psammophila affinis *K.*, skg. **C. Lepidoptera.** (*a*) *Noctuidae*: 14. Plusia gamma *L.*, skg. (*b*) *Rhopalocera*: 15. Lycaena aegon *S.-V.* ♂, skg.; 16. L. damon *S.-V.*, skg.

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands and at Kiel), Apis, 3 humble-bees, a Lepidopterid, and 6 hover-flies: (Rügen), all skg., a hover-fly (Volucella bombylans *L.*) and 3 bees (1. Apis mellifica *L.*; 2. Bombus agrorum *F.*; 3. B. lapidarius *L.* ♂ and ☿). Alfken (Bremen), 2 bees (Apis, freq., skg., and Megachile maritima *K.* ♀, skg.). Krieger (Leipzig), the bee Halictus smeathmanellus *K.* Rössler (Wiesbaden), the Noctuid moth Chariclea delphinii *L.* Friese, in Alsace (A.), Mecklenburg (M.), Thuringia (T.), and Hungary (H.), 3 bees—1. Eucera hungarica *Friese*, not rare (H.); 2. Osmia claviventris *Thoms.* ♂ (A., M., T., H.); 3. Osmia papaveris *Ltr.* (M. and T., occasional; H.). Loew (Silesia), an Asilid (Dioctria flavipes *Mg.*), a Muscid (Anthomyia sp.), and a bee (Apis mellifica *L.* ☿, po-cltg.) ('Beiträge,' p. 31). MacLeod (Flanders), Apis, 2 humble-bees, an Halictus, 6 hover-flies, an Empis, and 2 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 400–1). H. de Vries (Netherlands), the bee Apis mellifica *L.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875).

1573. **C. Scabiosa** L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 56–7; Herm. Müller, 'Fertilisation,' pp. 349–50, 'Weit. Beob.,' III, p. 80, 'Alpenblumen,' p. 416; Ljungström, Bot. Not. Lund, 1884; Loew, 'Blütenbiol. Floristik,' p. 393; Knuth, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Herbstbeob.')—The florets of this species are usually dull purple in colour, and Hermann Müller states that their mechanism corresponds on the whole to that of the hermaphrodite florets of C. Jacea. The ray-florets, however, are neuter, devoid of bells, and considerably larger, their corolla-tubes being 16–22 mm. in length. The nectar is even more easily accessible, for the corolla-tubes of the

disk-florets are 11–12 mm. long, and the bells 3½–4 mm. deep. Warnstorf describes the pollen-grains as resembling those of C. Jacea, but as much as 75 μ long and 44 μ broad. Purely female stocks with vestigial stamens in the disk-florets were observed by Ljungström in Sweden.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia, Thuringia, and Nassau.—

A. Coleoptera. *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, resting inactively on the florets (H. M.). **B. Diptera.** (*a*) *Empidae*: 2. Empis sp., freq., skg. (H. M., Thuringia). (*b*) *Muscidae*: 3. Trypeta cornuta *F.* (H. M.). (*c*) *Syrphidae*: 4. Eristalis horticola *Deg.*, po-dvg. (Budd.); 5. E. nemorum *L.* (H. M.). **C. Hemiptera.** 6. Capsus sp., skg. (H. M.). **D. Hymenoptera.** *Apidae*: 7. Anthidium manicatum *L.* ♀ and ♂, po-cltg. and skg. (H. M.); 8. Apis mellifica *L.* ☿, numerous, skg. (H. M.); 9. Bombus agrorum *F.* ♂ and ♀, skg. and po-dvg. (H. M.); 10. B. confusus *Schenck* ♂, skg. (H. M.); 11. B. lapidarius *L.* ♂, do. (H. M.); 12. B. sylvarum *L.* ♂, do. (H. M.); 13. B. terrester *L.* ♂ (H. M.); 14. Coelioxys conoidea *Ill.* ♂, freq., skg. (H. M.); 15. Halictus maculatus *Sm.* ♀, po-cltg. (H. M.); 16. H. quadricinctus *F.* ♀ and ♂, very common, skg. (H. M.); 17. Megachile argentata *F.* ♂, skg. (H. M., Strassburg); 18. M. ligniseca *K.* ♂, do. (H. M.); 19. Osmia aenea *L.* ♂ and ♀, po-cltg. and skg. (H. M.); 20. O. rufa *L.* ♀, do. (H. M., Strassburg); 21. O. spinulosa *K.* ♀, po-cltg. (H. M.); 22. Psithyrus rupestris *F.* ♂, skg. (H. M.). **E. Lepidoptera.** (*a*) *Rhopalocera*: 23. Epinephele janira *L.* (H. M.); 24. Lycaena corydon *Scop.*, skg. (H. M.); 25. Melanargia galatea *L.*, in large numbers, skg. (H. M.); 26. Melitaea athalia *Esp.* (H. M.). (*b*) *Sphingidae*: 27. Zygaena carniolica *Scop.* (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth (Glücksburg), 2 bees (Apis, and Bombus lapidarius *L.* ♀ and ♂) and a hover-fly (Eristalis tenax *L.*), skg.: (Kiel), a parasitic humble-bee (Psithyrus vestalis *Fourcr.*), 3 hover-flies (1. Eristalis sp.; 2. Helophilus pendulus *L.*; 3. Platycheirus peltatus *Mg.*), and 3 Lepidoptera (1. Lycaena sp.; 2. Plusia gamma *L.*; 3. Vanessa io *L.*), all skg., also the beetle Meligethes: (Rügen), 3 bees, all skg. (1. Bombus lapidarius *L.* ♀; 2. B. sylvarum *L.* ☿; 3. B. terrester *L.* ☿). Schmiedeknecht (Thuringia), the humble-bee Bombus derhamellus *K.* ♂. Schiner (Austria), 2 Muscids (Trypeta cornuta *F.*, and T. tussilaginis *F.*) and a Bombyliid (Phthiria gaedii *Mg.*). Schletterer and von Dalla Torre (Tyrol), 6 bees—1. Andrena eximia *Sm.*; 2. A. propinqua *Schenck*; 3. Halictus leucopus *K.* ♂; 4. H. sexcinctus *F.* ♂; 5. H. sexnotatus *K.* ♀; 6. Osmia spinulosa *K.* ♂. Herm. Müller (Switzerland), 2 beetles, 2 hover-flies, 12 bees, and 2 Lepidoptera. MacLeod (Pyrenees), 4 humble-bees, and 2 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 358). Loew (Steiermark), 3 bees (1. Bombus pratorum *L.* ♂, skg.; 2. B. variabilis *Schmiedekn.* ☿, po-cltg.; 3. Megachile melanopyga *Costa* ♀, do.) ('Beiträge,' p. 49): (Berlin Botanic Garden),—**A. Hymenoptera.** (*a*) *Apidae*: 1. Apis mellifica *L.*, skg.; 2. Bombus terrester *L.* ♂, do. (*b*) *Vespidae*: 3. Eumenes coarctatus *L.* **B. Lepidoptera.** *Rhopalocera*: all skg.: 4. Argynnis latonia *L.*; 5. Pieris brassicae *L.*; 6. Vanessa urticae *L.*; and on the var. *spinulosa*,—**A. Diptera.** *Syrphidae*: 1. Syritta pipiens *L.*; 2. Syrphus balteatus *Deg.* **B. Hymenoptera.** *Apidae*: 3. Psithyrus rupestris *F.* ♂, skg.

1574. C. nervosa Willd. (Herm. Müller, 'Alpenblumen,' pp. 415–16.)—The red heads of this species are 60–70 mm. in diameter. There are about 20 neuter ray-florets, modified into tubes 22 mm. long, with 5 lobes 15–20 mm. in length. There are about 100 disk-florets, each with a corolla-tube 8–9 mm. and a bell 5 mm. long. The flower mechanism agrees in other respects with that of C. Cyanus.

VISITORS.—Herm. Müller observed 5 humble-bees and 14 Lepidoptera in the Alps.

1575. C. Calcitrapa *L.* (Knuth, 'Bloemenbiol. Bijdragen.')—

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel Botanic Garden), the humble-bee Bombus lapidarius *L.* ♀, skg. Friese (Istria), the parasitic bee Crocisa major *Mor.* Schletterer (Pola), a Sphegid (Crabro clypeatus *L.*), and 4 bees (1. Crocisa major *Mor.*; 2. Halictus leucozonius *Schr.* ♀; 3. H. scabiosae *Rossi*; 4. Megachile apicalis *Spin.*).

1576. C. rhenana Bor. (=C. paniculata *Jacq.*, and C. maculosa *auct.*, *non Lam.*).—

Visitors.—Loew observed the following in Silesia ('Beiträge,' pp. 26–7).—

A. Coleoptera. *Chrysomelidae*: 1. Cryptocephalus sericeus *L.* **B. Diptera.** (*a*) *Bombyliidae*: 2. Bombylius minor *L.*, skg.; 3. Systoechus sulphureus *Mikan.*, do. (*b*) *Conopidae*: all skg.: 4. Myopa fasciata *Mg.*; 5. Physocephala nigra *Deg.* ♀; 6. P. truncata *Lw.* ♂; 7. P. vittata *F.* ♂. (*c*) *Stratiomyidae*: 8. Odontomyia hydroleon *L.*, skg. (*d*) *Syrphidae*: all skg.: 9. Eristalis tenax *L.*; 10. Syrphus lineola *Zett.*; 11. S. pyrastri *L.*; 12. Volucella bombylans *L.* **C. Hymenoptera.** (*a*) *Apidae*: 13. Andrena pilipes *F.* ♀, po-cltg. and skg.; 14. Bombus rajellus *K.* ☿, po-cltg.: 15. B. variabilis *Schmiedekn.* ☿, do.; 16. Coelioxys punctata *Lep.* ♀ and ♂, skg.; 17. Dasypoda hirtipes *F.* ♀ and ♂, do., ♀ actively po-cltg.; 18. Eucera (Tetralonia) pollinosa *Lep.* ♀, skg.; 19. Halictus leucozonius *Schr.* ♀, do.; 20. H. quadristrigatus *Ltr.* ♀, do.; 21. Megachile argentata *F.* ♂, do.; 22. M. fasciata *Sm.* ♂, do.; 23. M. maritima *K.* ♀, po-cltg.; 24. M. octosignata *Nyl.* ♀, do.; 25. Nomada jacobaeae *Pz.* ♀ and ♂, skg.; 26. Osmia solskyi *Mor.* ♀, do.; 27. Psithyrus rupestris *F.* ♀, do.; 28. Saropoda rotundata *F.* ♀, do. (*b*) *Sphegidae*: 29. Bembex rostrata *F.*, ♀ and ♂, skg. **D. Lepidoptera.** (*a*) *Noctuidae*: 30. Acronycta aceris *L.*, skg.; 31. Plusia gamma *L.*, do. (*b*) *Rhopalocera*: all skg.: 32. Argynnis aglaia *L.*; 33. Melanargia galatea *L.*; 34. Papilio machaon *L.*; 35. Pieris brassicae *L.*; 36. P. daplidice *L.*; 37. Vanessa cardui *L.*; 38. V. urticae *L.* (*c*) *Sphingidae*: 39. Ino statices *L.*, skg. Also (Tyrol), 3 Cerambycid beetles (1. Clytus ornatus *F.*; 2. C. plebeius *F.*; 3. Mylabris floralis *Pall.*).

The following were recorded by the observers, and for the localities stated.—

Gerstäcker (Chiavanna and Meran), 3 bees—1. Ceratina cucurbitina *Rossi*, freq., po-cltg.; 2. C. gravidula *Gerst.* ♀, po-cltg.; 3. Megachile melanopyga *Costa* ♀, po-cltg. Schletterer and von Dalla Torre (Tyrol), the same bees.

1577. C. arenaria Bieb.—

Visitors.—The following were recorded by the observers, and for the localities stated.—

Schletterer (Tyrol), 4 bees—1. Anthidium manicatum *L.*; 2. A. septemdentatum *Ltr.*; 3. Epeolus tristis *Sm.* (=E. luctuosus *Ev.*); 4. Melitta leporina *Pz.* Friese (Alps), the bee Eucera dentata *Klg.*: (Hungary), the bee E. graja *Ev.* Alfken (Bozen), the Pentatomid Carpoceris nigricornis *F.*, and 10 bees—1. Anthidium laterale *Ltr.*, in vast numbers, one on almost every capitulum, ♀ skg. and po-cltg., ♂ skg.; 2. A. manicatum *L.*, less freq., ♀ and ♂; 3. A. septemspinosum *L.*, rare; 4. Andrena carbonaria *L.* ♀, very common, skg. and po-cltg.; 5. Eriades crenulata *Nyl.* ♀, freq., po-cltg.; 6. Eucera dentata *Klug.* ♂, rare; 7. Megachile apicalis *Spin.*, exceedingly common, ♀ skg. and po-cltg., ♂ skg.; 8. M. lagopoda *L.* ♀, skg. and po-cltg.; 9. M. pilicrus *Mor.* ♀; 10. Xylocopa violacea *L.*, occasional.

1578. C. Bibersteinii Schur.—

Visitors.—Friese (Hungary) observed the following bees.—

Two parasitic species; 1. Ammobates vinctus *Gerst.*, freq.; 2. Pasites minutus *Mocs.*; and 8 po-cltg. forms; 3. Camptopoeum frontale *F.*, freq.; 4. Eucera graja *Ev.*: 5. Lithurgus chrysurus *Fonsc.*; 6. L. fuscipennis *Lep.*; 7. Osmia bidentata *Mor.*; 8. O. dives *Mocs.*; 9. O. spinulosa *K.*; 10. Podalirius bimaculatus *Pz.*

1579. **C. vallesiaca** Jord.—

Visitors.—Friese (Switzerland) observed the bee Podalirius bimaculatus *Pz.*, and the rare parasitic bee Stelis frey-gessneri *Friese.*

1580. **C. solstitialis** L.—

Visitors.—The following were recorded by the observers, and for the localities stated.—

Friese (Hungary), 5 bees—1. Lythurgus chrysurus *Fonsc.*; 2. L. fuscipennis *Lep.*; 3. Osmia bidentata *Mor.*; 4. O. dives *Mocs.*, occasional; 5. O. spinulosa *K.* Schletterer (Pola), a Sphegid (Crabro clypeatus *L.*) and 3 bees—1. Crocisa major *Mor.*; 2. Halictus calceatus *Scop.*; 3. Lithurgus chrysurus *Fonsc.*

1581. **C. amara** L.—

Visitors.—Schletterer observed the small bee Podalirius bimaculatus *Pz.* at Pola.

1582. **C. nigrescens** Willd.—

Visitors.—Schletterer records 3 bees for the Tyrol—1. Anthidium oblongatum *Ltr.*; 2. Andrena nitida *Fourcr.*; 3. Halictus calceatus *Scop.*

1583. **C. argentea** L.—

Visitors.—Loew observed 2 hover-flies (Eristalis arbustorum *L.*, and E. nemorum *L.*) in the Berlin Botanic Garden.

1584. **C. astrachanica** Spreng.—

Visitors.—Loew observed a humble-bee (Bombus terrester *L.* ♂, skg.) and a butterfly (Pieris brassicae *L.*, skg.) in the Berlin Botanic Garden.

1585. **C. atropurpurea** Waldst. et Kit.—

Visitors.—Loew (Berlin Botanic Garden) observed 2 bees—1. Bombus pratorum *L.* ♂, skg.; 2. B. terrester *L.* ♂, do. (also on the var. *ochroleuca*).

1586. **C. calocephala** Willd.—

Visitors.—Loew (Berlin Botanic Garden) observed a beetle (Cetonia aurata *L.*), 2 hover-flies (Eristalis tenax *L.*, and Syritta pipiens *L.*), and a butterfly (Vanessa urticae *L.*, skg.).

1587. **C. conglomerata** C. A. Mey.—

Visitors.—Loew (Berlin Botanic Garden) observed a humble-bee (Bombus terrester *L.* ♂, skg.) and a butterfly (Epinephele janira *L.*, skg.).

1588. **C. dealbata** Willd.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Syrphus pyrastri *L.* **B. Hymenoptera.** *Apidae*: 2. Apis mellifica *L.* ☿, skg. and po-cltg.; 3. Megachile centuncularis *L.* ♀, po-cltg.; 4. Osmia fulviventris *Pz.* ♀, do.; Prosopis communis *Nyl.* ♂, skg.

1589. **C. Endresii** Hochst. et Steud.—

Visitors.—Loew observed a hover-fly (Syrphus corollae *F.*) in the Berlin Botanic Garden.

1590. C. Fischeri Willd.—

VISITORS.—Loew observed the following bees in the Berlin Botanic Garden.—

1. Anthidium manicatum *L.* ♀, po-dvg.; 2. Apis mellifica *L.* ☿, skg.; 3. Megachile lagopoda *L.* ♂, do.; 4. Osmia fulviventris *Pz.* ♂, do.; 5. O. papaveris *Ltr.* ♂, do.; 6. Stelis phaeoptera *K.* ♀, do.: also the wasp Odynerus parietum *L.* ♀ and ♂.

1591. C. Fontanesii Spach.—

VISITORS.—Loew observed a hover-fly (Syrphus balteatus *Deg.*) in the Berlin Botanic Garden.

1592. C. leucolepis DC.—

VISITORS.—Loew observed a humble-bee (Bombus pratorum *L.* ♂, skg.) in the Berlin Botanic Garden.

1593. C. microptilon Godr. et Gren.—

VISITORS.—Loew (Berlin Botanic Garden) observed a hover-fly (Syrphus ribesii *L.*) and a bee (Halictus cylindricus *F.* ♂, skg.).

1594. C. ochroleuca Pushk.—

VISITORS.—Loew observed a bee (Osmia fulviventris *Pz.* ♂, skg.) in the Berlin Botanic Garden.—

1595. C. orientalis L.—

VISITORS.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. Syrphus balteatus *Deg.* **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg.; 4. Psithyrus rupestris *F.* ♂, do.; 5. P. vestalis *Fourcr.* ♂, do. **C. Lepidoptera.** *Rhopalocera*: 6. Vanessa urticae *L.*, skg.

1596. C. rigidifolia Bess.—

VISITORS.—Loew (Berlin Botanic Garden) observed a hover-fly (Eristalis intricarius *L.*) and a bee (Psithyrus rupestris *F.* ♂, skg.).

1597. C. rupestris L.—

VISITORS.—Loew (Berlin Botanic Garden) observed a beetle (Cetonia aurata *L.*) and a bee (Bombus terrester *L.* ♂, skg.).

1598. C. ruthenica Lam.—

VISITORS.—Loew (Berlin Botanic Garden) observed 2 hover-flies (Syritta pipiens *L.*, and Syrphus corollae *F.*) and 2 bees (Bombus terrester *L.* ♂, skg., and Megachile lagopoda *L.* ♀, po-cltg.

1599. C. salicifolia Bieb.—

VISITORS.—Loew (Berlin Botanic Garden) observed a humble-bee (Bombus terrester *L.* ☿. skg.) and 2 butterflies (Argynnis latonia *L.*, skg., and Pararge megaera *L.*).

1600. C. salonitana Vis.—

VISITORS.—Loew (Berlin Botanic Garden) observed a bee (Osmia fulviventris *Pz.* ♀, po-cltg.) and a butterfly (Pieris brassicae *L.*, skg.).

1601. C. stereophylla Bess.—

VISITORS.—Loew observed the parasitic humble-bee Psithyrus vestalis *Fourcr.* ♂, skg., in the Berlin Botanic Garden.

480. Xeranthemum Tourn.

Short conical tip of the style of the hermaphrodite disk-florets covered as far down as the cleft with sweeping-hairs directed obliquely upwards; inner surfaces of the stylar branches beset with stigmatic papillae. There are neither stigmatic papillae nor sweeping-hairs on the styles of the neuter ray-florets.

1602. **X. annuum** L. (Sprengel, 'Entd. Geh.,' p. 371; Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 48–50, Taf. V, Figs. 24–30.)—Sprengel regarded the ray-florets of this species as female, but Hildebrand says that their ovary, though fairly well developed, never contains an ovule. In the second stage of anthesis the stylar branches diverge and expose their papillose stigmatic surfaces to insects.

B. Liguliflorae Less. (= *Cichoriaceae* Juss.)

Florets all ligulate and hermaphrodite; style unjointed, its filiform branches are covered with soft hairs, and become reflexed. Kirchner observed that the species of this group present a marked agreement as regards their flower mechanism. The corolla is a tube closed above, before the florets open; it is split on the inner side and produced into a ligulate expansion. When the style grows through the anther-cylinder, it does not push the pollen before it, but becomes covered with this on its outer surface, which is beset with sweeping-hairs. With regard to insect-visits Hermann Müller remarks that as the anther-cylinders usually project for several mm., and the styles as much further, most of the visitors creep about between the ends of the latter rather than over them, so as to transfer pollen with their sides rather than their ventral surfaces. The simultaneous pollination of numerous florets therefore takes place to a less extent than among the Senecionidae and Asteroideae, where heaps of pollen are succeeded by the stigmatic surfaces at the same level. On the other hand, the florets of the Ligulatae can simultaneously receive pollen brought by insect visitors and dust these with their own pollen.

The yellow-flowered species of the group are visited with special eagerness by bees of the genus Panurgus.

481. Catananche L.

1603. **C. lutea** L. (Murbeck, Vet.-Ak. Öfvers., Stockholm, lviii, 1901–2.)—Murbeck states that in this Mediterranean species subterranean heads are borne in the axils of the outer leaves of the rosette. These only contain 1–3 cleistogamous florets.

482. Lampsana Tourn.

Florets yellow. Style covered externally with sweeping-hairs, which extend a long way down, and closely beset with stigmatic papillae internally.

1604. **L. communis** L. (= *Lapsana communis L.*). (Herm. Müller, 'Fertilisation,' pp. 351–2, 'Weit. Beob.,' III, pp. 97–8; Kirchner, 'Flora v. Stuttgart,' p. 733; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, v, 1893; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 96, 191; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In this species the heads are solitary, and not very conspicuous. Hermann

Müller says that they contain only 8–17 florets with corolla-tubes $1\frac{1}{2}$–$2\frac{1}{2}$ mm. and ligules 4–6 mm. long, the whole diameter being only 8–10 mm. The style projects $1\frac{1}{2}$–2 mm. from the anther-cylinder, which in turn exceeds the corolla-tube by 2–3 mm. The stylar branches are only $\frac{1}{2}$ mm. long. During the second stage of anthesis, they diverge widely in such a way that automatic self-pollination is regularly effected, if insect visitors have not previously removed the pollen. Kerner states that the heads open between 6 and 7 a.m. in favourable weather, closing again as early as 10 or 11 o'clock in the forenoon; in unfavourable weather they remain completely closed. According to Warnstorf, they open between 6 and 7 a.m. at Neu-Ruppin, and close again between 3 and 4 p.m. The pollen-grains are yellow in colour, and polyhedral; they bear spinose tubercles on their edges, and average 31 μ in diameter.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands) 3 hover-flies. Herm. Müller (Westphalia), 3 po-dvg. hover-flies (1 Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. sepulcralis *L.*); Buddeberg (Nassau), a hover-fly (Ascia podagrica *F.*, po.-dvg.), and 3 bees (1. Halictus leucozonicus *Schr.*, po-cltg.; 2. H. morio *F.* ♂, skg.; 3. H. smeathmanellus *K.* ♀, do.). MacLeod (Flanders), a hover-fly, 3 Muscids, and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 428); (Pyrenees), a Muscid (op. cit., iii, 1891, p. 364). Scott-Elliott (Dumfriesshire), a short-tongued bee, a hover-fly, and 3 Muscids ('Flora of Dumfriesshire,' p. 108).

483. Aposeris Neck.

1605. A. foetida Less. (= Hyposeris foetida *L.*, and Lampsana foetida *F. W. Schmidt*). (Briquet, 'Études de biol. flor. dans les Alpes occident.')—Briquet says that in this species the head contains 10–25 yellow florets, and has a diameter of 25–30 mm. Each floret possesses a ligule 13–15 mm. and a corolla-tube 2–$2\frac{1}{2}$ mm. in length. The anther-cylinder is about 4 mm. long, and the style projects as far beyond it, ultimately rolling back its branches so far that they can be self-pollinated.

VISITORS.—Few in number. Kirchner says they are beetles, Diptera, and even humble-bees, which effect both cross- and self-pollination.

484. Arnoseris Gaertn.

Heads small and yellow. Style (below the cleft) covered with short sweeping-hairs that stand out horizontally; inner surfaces of the stylar branches beset with stigmatic papillae.

1606. A. minima Dum. (=A. pusilla *Gaertn.*, and Hyoseris minima *L.*). (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 96, 161; 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 229.)—The heads of this species examined by me in the island of Föhr were 8 mm. in diameter. They consisted of 20–5 florets, each 6 mm. in length; the ligule was 3 mm. long and $1\frac{1}{2}$ mm. broad. In the second stage of anthesis the stylar branches diverge in a crescentic manner.

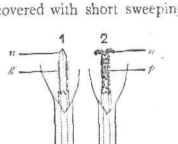


FIG. 208. *Arnoseris minima, Dum.* (from nature, enlarged). (1) Stylar branches (*n*) closed; *g*, stylar brush. (2) Do., diverging; *p*, pollen-grains on the brush.

VISITORS.—Knuth (Föhr) saw 2 hover-flies and a minute Muscid; MacLeod (Flanders), a small fly (Bot. Jaarb. Dodonaea, Ghent, vi, 1894, p. 374).

485. Hyoseris L.

1607. **H. radiata** L.—

VISITORS.—Delpino observed the bee Megachile centuncularis *L.* ('Ult. oss.,' p. 125).

486. Anandria Siegesb.

As Linnaeus had already recognized there are cleistogamous flowers in species of this genus (H. von Mohl, Bot. Ztg., Leipzig, xxi, 1863).

487. Cichorium L.

Florets blue in colour, rarely red or white. The style is covered externally with strong sweeping-hairs directed obliquely upwards and extending for some distance below the cleft: inner surfaces of the branches beset with stigmatic papillae.

1608. **C. Intybus** L. (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' p. 10, Taf. I, Figs. 8–10; Herm. Müller, 'Fertilisation,' p. 351, 'Weit. Beob.,' III, p. 97; Loew, 'Blütenbiol. Floristik,' p. 390; Knuth, 'Bloemenbiol. Bijdragen,' 'Blütenbiol. Herbstbeob.'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896.)—In this species the heads display in the sunshine a disk about 30 mm. broad, and usually blue in colour. They contain relatively few florets, but the ligules are 12–14 mm. in length, though the corolla-tubes are only 3 mm. long. In the second stage of anthesis the stylar branches are twisted into a spiral of 1–2 coils, so that the inner stigmatic surfaces come into contact with the pollen-grains that remain among the sweeping-hairs, and automatic self-pollination is thus effected in the absence of insect visitors.

The capitula, according to Linnaeus, open about 5 o'clock a.m. at Upsala, closing again at 10 o'clock in the forenoon; at Innsbruck, according to Kerner, they only open about 6–7 a.m., and close again at 2–3 p.m. Warnstorf says that they open at Neu-Ruppin between 6 and 7 a.m. The pollen-grains are white in colour, polyhedral, with spinose tubercles on their edges, and their average diameter is 46 μ.

VISITORS.—Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Coleoptera. *Telephoridae*: 1. Malachius bipustulatus *L.*, freq., po-dvg. (H. M.). **B. Diptera.** (*a*) *Conopidae*: 2. Sicus ferrugineus *L.*, skg. (H. M.). (*b*) *Syrphidae*: 3. Eristalis tenax *L.*, skg. and po-dvg. (H. M.); 4. Syritta pipiens *L.* do. (H. M.). **C. Hymenoptera.** *Apidae*: 5. Andrena fulvicrus *K.* ♀, po-cltg. (H. M.); 6. Apis mellifica *L.* ☿, freq., skg. (H. M.); 7. Chelostoma campanularum *L.* ♀ (Budd.); 8. Dasypoda hirtipes *F.* ♂, skg. (H. M.); 9. Halictus albipes *F.* ♂, do. (H. M.); 10. H. cylindricus *F.* ♀, do. (H. M.); 11. H. interruptus *Pz.* ♀, do. (H. M., Thuringia); 12. H. leucozonius *Schr.* ♂, do. (Budd.); 13. H. longulus *Sm.* ♀, do. (H. M.); 14. H. nitidiusculus *K.* ♂, do. (H. M.); 15. H. quadricinctus *F.* ♂, do. (H. M.); 16. H. rubicundus *Chr.* ♂, do. (H. M.); 17. H. smeathmanellus *K.* ♀, do. (H. M., Bavarian Oberpfalz); 18. H. tetrazonius *Klg.* ♀, do. (H. M., Bavarian Oberpfalz); 19. Osmia adunca *Pz.* ♂, do. (H. M., Kitzingen); 20. O. spinulosa *K.* ♀, not infrequent, skg. and

po-cltg. (H. M., Thuringia); 21. Prosopis nigrita *F.* ♂, in large numbers, skg. (H. M., Bavarian Oberpfalz). **D. Lepidoptera.** *Rhopalocera*: 22. Colias hyale *L.*, skg. (H. M., Thuringia).

The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel), 6 skg. and po-dvg. hover-flies—1. Eristalis sp.; 2. Melanostoma sp.; 3. Platycheirus podagratus *Zett.*, 4. Syrphus balteatus *Deg.* ♂; 5. S. ribesii *L.*; 6. S. umbellatarum *F.* Alfken (Bremen), 4 bees—1. Eriades nigricornis *Nyl.* ♀; 2. Halictus calceatus *Scop.* ♂; 3. H. flavipes *Pz.* ♀; 4. H. morio *F.* ♀. Schenck (Nassau), 4 bees—1. Anthidium punctatum *Ltr.*; 2. Halictus leucozonius *Schr.*; 3. H. lucidulus *Schenck*; 4. H. sexnotatulus *Nyl.* (=H. quadrifasciatus *Schenck*). Friese, the bee Panurgus banksianus *K.*: (Alsace), the bee Dasypoda plumipes *Pz.* Loew (Brandenburg) ('Beiträge,' p. 39), a hover-fly (Eristalis sepulcralis *L.*) and 3 bees (1. Dasypoda hirtipes *F.* ♂, skg.; 2. Halictus cylindricus *F.* ♂, do.; 3. H. sexnotatus *K.* ♂, do.).

1609. C. Endivia L. (Knuth, 'Blütenbiol. Herbstbeob.')—The flower mechanism of this species agrees with that of C. Intybus. The blue florets develop to a great size and spread out their ligules to attract insects, while the reproductive organs form a circle in the middle of the inflorescence. In both species the ligules are about 2 cm. long and 6–7 mm. broad. In C. Endivia the diameter of the head is 4–5 cm.; while in C. Intybus it is somewhat smaller as a rule. The number of florets in an inflorescence is 20–30 in the former species, 12–20 in the latter.

VISITORS.—Knuth observed a hover-fly (Eristalis sp.) and a butterfly (Pieris sp.).

488. Thrincia Roth.

1610. T. hirta Roth (=Leontodon hirtus L.).—

VISITORS.—Herm. Müller gives the following list for Westphalia and the Bavarian Oberpfalz ('Fertilisation,' pp. 358–9, 'Weit. Beob.,' III, p. 97).—

A. Coleoptera. *Buprestidae*: 1. Anthaxia quadripunctata *L.*, *in copulâ* on the florets. **B. Diptera.** *Syrphidae*: 2. Eristalis arbustorum *L.*, freq., skg. and po-dvg.; 3. E. sepulcralis *L.*, po-dvg.; 4. E. tenax *L.*, freq., skg. and po-dvg.; 5. Syrphus balteatus *Deg.*, do. **C. Hymenoptera.** (*a*) *Apidae*: 6. Andrena denticulata *K.* ♀, skg. and po-dvg. (Sld., Thüringia); 7. A. fulvago *Chr.* ♀, po-cltg. (Thuringia); 8. A. fulvescens *Sm.* ♀, do. (Thuringia); 9. A. fulvicrus *K.* ♀, po-cltg.; 10. Bombus confusus *Schenck* ♂, skg.; 11. B. tristis *Seidl.* ♂, do. (Liebenau near Schwiebus); 12. Cilissa melanura *Nyl.* ♀; 13. Dasypoda hirtipes *F.* ♂, skg. (Liebenau near Schwiebus); 14. Dufourea vulgaris *Schenck* ♀ and ♂, po-cltg. and skg.; 15. Halictus cylindricus *F.* ♀ and ♂, do.; 16. H. flavipes *F.* ♂, skg.; 17. H. leucozonius *Schr.* ♀ and ♂, very numerous, skg. and po-cltg. (Thuringia); 18. H. lugubris *K.* ♂, skg.; 19. H. maculatus *Sm.* ♂, do.; 20. H. sexcinctus *F.* ♀, skg. and po-cltg.; 21. H. smeathmanellus *K.* ♀, po-cltg.; 22. H. villosulus *K.* ♀, do.; 23. Panurgus calcaratus *Scop.* ♀ and ♂, freq., po-cltg. and skg. (*b*) *Sphegidae*: 24. Cerceris variabilis *Schr.* ♀, skg. **D. Lepidoptera.** (*a*) *Noctuidae*: 25. Plusia gamma *L.*, skg. (*b*) *Rhopalocera*: 26. Pieris napi *L.*, skg.

The following were recorded by the observers, and for the localities stated.—

Alfken and Höppner (Bremen), 10 bees—1. Bombus agrorum *F.* ♀; 2. B. arenicola *Ths.* ☿; 3. B. lapidarius *L.* ☿; 4. B. sylvarum *L.* ☿; 5. B. variabilis *Schmiedekn.* ☿; 6. Halictus calceatus *Scop.* ♀ and ♂; 7. H. flavipes *F.* ♀ and ♂; 8. H. leucozonius *Schr.* ♀ and ♂; 9. H. rubicundus *Chr.* ♀ and ♂; 10. H. zonulus *Sm.* ♀ and ♂. MacLeod (Flanders), 2 humble-bees, 5 hover-flies, a Muscid, and 3 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 428–9).

489. Leontodon L.

Florets yellow. Styles rather closely covered outside with sharp sweeping-hairs extending far above the cleft; inner surfaces of the stylar branches—which sometimes do not entirely separate—densely beset with stigmatic papillae. Kerner states that geitonogamy by pollen from the inner florets is automatically effected by the spreading of the stylar branches. He further remarks that automatic self-pollination may also be brought about by gradual elongation of the ligulate corolla, which thus carries up the pollen adhering to it.

FIG. 209. *Leontodon autumnalis, L.* (after Herm. Müller). (1) Floret in the second (female) stage, after removal of calyx and ovary (× 7). (2) End of style of do. (× 35). *a*, sweeping-hairs; *b*, stigmatic papillae; *c*, pollen-grains.

1611. **L. autumnalis** L. (Herm. Müller, 'Fertilisation,' pp. 356–8, 'Weit. Beob.,' III, pp. 96–7; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 96–7, 161, 'Bl. u. Insekt. a. d. Halligen,' p. 37, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 236–7, 'Blütenbiol. Beob. a. d. Ins. Rügen,' 'Bloemenbiol. Bijdragen'; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt Blomn. o. Befrukt.'; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; MacLeod, Bot. Jaarb. Dodonaea, Ghent, v, 1893.)—The heads of this species expand in the sunshine to form a golden-yellow disk 20–30 mm. broad, but in rainy weather they contract to a diameter of 5 mm. Hermann Müller says that each head contains 40–70 florets, with corolla-tubes $2\frac{1}{2}$–5 mm. and ligules 7–12 mm. long. The style projects 3–4 mm. beyond the tube, into the wider part of which the nectar rises. If insect-visitors are sufficiently numerous at the right time, the pollen is removed from the sweeping-hairs before the stigmatic surfaces unfold; at a later stage insects may effect self-pollination. The latter may also take place automatically should insect-visits fail, by the stigmatic surfaces coming into contact with the pollen.

VISITORS.—Knuth observed the following in Schleswig-Holstein (S.-H.), Rügen (R.), and the dunes and high land of Helgoland (H.).—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, po-dvg. (R.). (*b*) *Telephoridae*: 2. Psilothrix cyanea *Ol.*, po-dvg. (H.). **B. Diptera.** (*a*) *Muscidae*:

3. Anthomyia sp. (S.-H.); 4. Aricia incana *Wied.* (S.-H.); 5. Coleopa frigida *Fall.* (H.).; 6. Lucilia caesar *L.* (H.); 7. Sarcophaga sp. (S.-H.); 8. Scatophaga stercoraria *L.* (S.-H.); 9. Small Muscids (S.-H.). (*b*) *Syrphidae*: all skg. and po-dvg.: 10. Eristalis arbustorum *L.* (S.-H.); 11. E. sp. (S.-H.); 12. E. tenax *L.* (S.-H.); 13. Helophilus pendulus *L.* (S.-H.); 14. H. trivittatus *F.* ♀ (S.-H.); 15. Syrphus balteatus *Deg.* (S.-H.); 16. S. ribesii *L.* (S.-H. and R.); 17. Volucella bombylans *L.* (S.-H.). **C. Hymenoptera.** *Apidae*: all skg. or po-cltg.: 18. Apis mellifica *L.* (S.-H.); 19. Bombus agrorum *F.* (S.-H.); 20. B. derhamellus *K.* ♀ (S.-H.); 21. B. lapidarius *L.* (S.-H.); 22. Colletus daviesanus *K.* (S.-H.); 23. Dasypoda plumipes *Pz.* (S.-H.); 24. Panurgus banksianus *K.* (S.-H.); 25. P. calcaratus *Scop.* (=P. lobatus *F.*) (S.-H. and R.). **D. Lepidoptera.** All skg. (*a*) *Hesperidae*: 26. Hesperia lineola *O.* (R.). (*b*) *Microlepidoptera*: 27. Tortrix sp. (S.-H.). (*c*) *Noctuidae*: 28. Plusia gamma *L.* (S.-H.). (*d*) *Rhopalocera*: 29. Argynnis adippe *L.* (R.); 30. A. paphia *L.* (R.); 31. Epinephele janira *L.* (S.-H.); 32. Pieris sp. (S.-H.); 33. Polyommatus phlaeas *L.* (S.-H.). (*e*) *Sphingidae*: 34. Zygaena filipendula *L.* (S.-H.); Z. 2 sp. (R.). And in Thuringia ('Blütenbiol. Beob. in Thüringen,' p. 36).—**A. Diptera.** (*a*) *Muscidae*: all skg. and po-dvg.: 1. Aricia basalis *Zett.*, freq.; 2. A. serva *Mg.* (*b*) *Syrphidae*: 3. Eristalis pertinax *Scop.* ♀; 4. Syrphus annulipes *Zett.* ♀; 5. S. ribesii *L.* ♂. **B. Hymenoptera.** *Apidae*: all skg. or po-cltg.: 6. Bombus lapidarius ☿; 7. B. soroënsis *F.*, var. proteus *Gerst.* ☿; 8. B. terrester *L.* ♀; 9. Halictus leucozonius *Schr.* ♀; 10. Psithyrus vestalis *Fourcr.* ♂. **C. Lepidoptera.** All skg.: 11. Argynnis adippe *L.*; 12. A. paphia *L.*; 13. Epinephele janira *L.*; 14. Pieris sp.; 15. Vanessa urticae *L.*

Alfken observed the following at Bremen.—

A. Diptera. (*a*) *Bombyliidae*: 1. Exoprosopis capucina *L.* (*b*) *Syrphidae*: 2. Eristalis anthophorinus *Zett.*; 3. E. intricarius *L.*; 4. Helophilus pendulus *L.*; 5. Melanostoma mellina *L.* **B. Hymenoptera.** (*a*) *Apidae*: 6. Andrena argentata *Sm.* ♀; 7. A. combinata *Chr.* ♂; 8. A. denticulata *K.* ♀, freq., skg. and po-cltg.; 9. A. flavipes *K.*, 2nd gen., freq., ♀ skg. and po-cltg., ♂ skg.; 10. A. marginata *F.* ♂; 11. A. parvula *K.* ♀; 12. A. propinqua *Schenck*, 2nd gen. ♀ and ♂; 13. A. shawella *K.* ♀ and ♂; 14. A. tarsata *Nyl.* ♀ and ♂; 15. Bombus agrorum *F.* ☿; 16. B. derhamellus *K.* ☿, po-cltg.; 17. B. distinguendus *Mor.* ☿ and ♂; 18. B. lapidarius *L.* ☿ and ♂; 19. B. lucorum *L.* ☿; 20. B. muscorum *F.* ☿; 21. B. proteus *Gerst.* ☿ and ♂; 22. B. sylvarum *L.*; 23. Coelioxys acuminata *Nyl.* ♂; 24. Colletes daviesanus *K.* ♀ and ♂; 25. Dasypoda plumipes *Pz.*, freq., ♀ skg. and po-cltg., ♂ skg.; 26. Dufourea vulgaris *Schenck*, very common, ♀ skg. and po-cltg.; 27. Epeolus variegatus *L.* ♂; 28. Eriades truncorum *L.* ♀, po-cltg.; 29. Halictoides inermis *Nyl.* ♂; 30. Halictus calceatus *Scop.* ♀ and ♂, very common; 31. H. brevicornis *Schenck* ♀, rare; 32. H. flavipes *F.* ♀ and ♂, freq.; 33. H. levis *K.* ♀ and ♂; 34. H. leucopus *K.* ♀; 35. H. leucozonius *Schr.*, very common, ♀ skg. and po-cltg., ♂ skg.; 36. H. malachurus *K.* ♂; 37. H. minutissimus *K.* ♂; 38. H. minutus *K.* ♂; 39. H. punctulatus *K.* ♀ and ♂, very common; 40. H. rubicundus *Chr.* ♂; 41. H. quadrinotatulus *Schenck* ♀; 42. H. semipunctulatus *Schenck* ♀; 43. H. sexnotatus *Nyl.* ♀; 44. H. tumulorum *L.* ♂; 45. H. zonulus *Sm.* ♀; 46. Megachile maritima *K.* ♀, po-cltg.; 47. Melitta leporina *Pz.*, rare, ♀ po-cltg., ♂ skg.; 48. Nomada fuscicornis *Nyl.* ♀ and ♂; 49. N. solidaginis *Pz.* ♀, skg.; 50. Osmia solskyi *Mor.* ♀; 51. Panurgus banksianus *K.* ♀ and ♂, very common; 52. P. calcaratus *Scop.* ♀ and ♂, do.; 53. Psithyrus barbutellus *K.* ♂; 54. P. rupestris *F.* ♂; 55. P. vestalis *Fourcr.* ♂; 56. Trachusa serratulae *Pz.* ♂. (*b*) *Sphegidae*: 57. Crabro albilabris *F.* ♀; 58. C. palmarius *Schreb.* ♀; 59. Diodontus tristis *v. d. L.* ♂.

Herm. Müller gives the following list for Westphalia and the Bavarian Oberpfalz.—

A. Diptera. (*a*) *Bombyliidae*: 1. Systoechus sulphureus *Mik.*, skg. (*b*) *Conopidae*: 2. Sicus ferrugineus *L.*, skg. (*c*) *Muscidae*: 3. Sarcophaga carnaria *L.*, skg. (*d*) *Syrphidae*: 4. Eristalis arbustorum *L.*, very common, skg. and po-dvg.; 5. E. sepulcralis

L., do.; 6. E. tenax *L.*, do.; 7. Melithreptus taeniatus *Mg.*, do.; 8. Syrphus balteatus *Deg.*, do.; 9. S. nitidicollis *Mg.*, do.; 10. S. pyrastri *L.*, freq., do.; 11. Volucella bombylans *L.*, do. **B. Hymenoptera.** (*a*) *Apidae*: 12. Andrena fulvicrus *K.* ♀, po-cltg.; 13. Apis mellifica *L.* ☿, skg.; 14. Bombus agrorum *L.* ♀, do.; 15. B. lapidarius *L.* ☿, do.; 16. Dasypoda hirtipes *F.* ♀, po-cltg.; 17. Diphysis serratulae *Pz.* ♀ and ♂, occasional, skg.; 18. Dufourea vulgaris *Schenck* ♀ and ♂, po-cltg. and skg.; 19. Halictus cylindricus *F.* ♂, skg.; 20. H. leucopus *K.* ♀, skg. and po-cltg.; 21. H. leucozonius *Schr.* ♀, do.; 22. H. longulus *Sm.* ♀, do.; 23. H. maculatus *Sm.* ♂, skg.; 24. H. morio *F.* ♂, do.; 25. H. smeathmanellus *K.* ♂, do.; 26. H. villosulus *K.* ♀, skg. and po-cltg.; 27. Panurgus banksianus *K.* ♀, po-cltg.; 28. P. calcaratus *Scop.*, skg. and po-cltg., often resting inactively among the florets; 29. Prosopis armillata *Nyl.* ♂, skg.; 30. Sphecodes gibbus *L.* ♀ and ♂, skg. and po-dvg. (*b*) *Sphegidae*: 31. Pompilus viaticus *L.*, skg. **C. Lepidoptera.** (*a*) *Noctuidae*: 32. Plusia gamma *L.*, skg. (*b*) *Rhopalocera*: 33. Argynnis aglaia *L.*, freq., skg.; 34. Colias hyale *L.*, skg. (Thuringia).

H. de Vries observed the following 11 bees in the Netherlands (Ned. Kruidk. Arch., Nijmegen, 2 Ser., 2. Deel, 1875).—

1. Bombus subterraneus *L.* ☿; 2. B. terrester *L.* ☿; 3. Chelostoma florisomne *L.* ♂; 4. Halictus cylindricus *F.* ♂; 5. H. leucozonius *Schr.* ♀; 6. H. nitidiusculus *K.* ♂; 7. H. villosulus *K.* ♀; 8. H. zonulus *Sm.* ♀; 9. Nomada fabriciana *L.* ♂; 10. Panurgus banksianus *K.* ♂; 11. Prosopis communis *Nyl.* ♀.

Willis noticed the following in the neighbourhood of the south coast of Scotland ('Fls. and Insects in Gt. Britain,' Part I).—

A. Coleoptera. *Curculionidae*: 1. Sitona puncticollis *Steph.* **B. Diptera.** (*a*) *Muscidae*: 2. Anthomyia radicum *L.*; 3. A. sp.; 4. Hydrellia griseola *Fall.*; 5. Tricophthicus cunctans *Mg.* (*b*) *Mycetophilidae*: 6. Sciara sp. (*c*) *Syrphidae*: 7. Brachyopa bicolor *Fall.*; 8. Eristalis aeneus *Scop.*; 9. E. pertinax *Scop.*; 10. E. tenax *L.*; 11. Platycheirus manicatus *Mg.*; 12. Sericomyia borealis *Fall.*; 13. Sphaerophoria scripta *L.*; 14. Syrphus ribesii *L.*; 15. S. sp. **C. Hemiptera.** 16. Acocephalus sp.; 17. Calocoris bipunctatus *F.*; 18. C. fulvomaculatus *Deg.*; 19. Miris levigatus *L.* **D. Hymenoptera.** (*a*) *Apidae*: 20. Bombus agrorum *F.*; 21. B. terrester *L.*; 22. Halictus rubicundus *Chr.* (*b*) *Ichneumonidae*: 23. Ichneumon sp. **E. Lepidoptera.** (*a*) *Microlepidoptera*: 24. Crambus sp.; 25. Simaëthis fabriciana *Steph.* (*b*) *Rhopalocera*: 26. Lycaena icarus *Rott.*

The following were recorded by the observers, and for the localities stated.—

Sickmann (Osnabrück), the fossorial wasp Mellinus arvensis *L.* Verhoeff (Norderney), 2 hover-flies (Melithreptus menthastri *L.* ♀, and Syrphus ribesii *L.* ♀). von Dalla Torre (Innsbruck Botanic Garden), the bee Halictus leucozonius *Schr.* ♂. MacLeod (Flanders), 3 humble-bees, 2 sp. of Halictus, 6 hover-flies, and 3 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 429). Scott-Elliot (Dumfriesshire), 2 humble-bees, numerous bees and flies ('Flora of Dumfriesshire,' p. 102).

1612. L. hastilis L. (Kirchner, 'Flora v. Stuttgart,' p. 735.)—Kirchner states that the heads of this species contain from 40 to over 80 florets, and spread out in the forenoon in sunny weather into a golden-yellow disk of 20–25 mm. broad. The corolla-tube is 4–6 mm. and the ligule 8–12 mm. long. The anther-cylinder projects 3–4 mm. from the corolla-tube, and the style extends 4–5 mm. further. The stylar branches are 2 mm. long, and finally roll back to form a spiral of $1\frac{1}{2}$ turns. Warnstorf describes the pollen-grains as pure yellow in colour, polyhedral, and spinose, measuring about $37 \cdot 5\ \mu$ in diameter.

VISITORS.—Herm. Müller gives the following list for Westphalia ('Fertilisation,' p. 358).—

A. Diptera. (*a*) *Bombyliidae*: 1. Systoechus sulphureus *Mik.*, skg. (Sauerland). (*b*) *Conopidae*: 2. Sicus ferrugineus *L.*, skg. (*c*) *Syrphidae*: 3. Cheilosia sp.; 4. Eristalis arbustorum *L.*, very common, po-dvg. and skg.; 5. E. horticola *Deg.*, po-dvg. and skg.; 6. Melithreptus taeniatus *Mg.*, do.; 7. Sericomyia lappona *L.*, skg. (Sauerland); 8. Volucella pellucens *L.*, in large numbers, skg. (Sauerland). **B. Hymenoptera.** (*a*) *Apidae*: 9. Andrena coitana *K.* ♀ and ♂, skg. and po-cltg.; 10. A. fulvescens *Sm.* ♀, do., dusting itself with large quantities of pollen; 11. Psithyrus barbutellus *K.* ♀, skg.; 12. Bombus pratorum *L.* ☿, skg. and po-cltg.; 13. Halictus albipes *F.* ♀, po-cltg.; 14. A. cylindricus *F.* ♀, freq., po-cltg.; 15. H. leucozonius *Schr.* ♀, po-cltg.; 16. H. smeathmanellus *K.* ♀, do.; 17. H. villosulus *K.* ♀, do. (*b*) *Tenthredinidae*: 18. Tenthredo sp., skg. **C. Lepidoptera.** *Rhopalocera*: 19. Hesperia sylvanus *Esp.*, skg.

The following were recorded by the observers, and for the localities stated.—

MacLeod (Pyrenees), 9 bees, 7 Lepidoptera, 3 beetles, and 7 Muscids. Frey-Gessner (Switzerland), the rare dasygastrid bee Eriadis grandis *Nyl.* Schenck (Nassau), the bee Osmia leucomelaena *K.* Loew (Rügen), the bee Panurgus lobatus *F.* ♂, skg. ('Beiträge,' p. 40): Silesia, the hover-fly Pipiza noctiluca *L.* (?), and the bee Anthidium strigatum *Pz.* (op. cit., p. 32); Riesengebirge (R.) and Silesia (S.), the hover-fly Cheilosia canicularis *Pz.*, skg. (R.), and the bee Andrena shawella *K.* ♀, skg. (S.) (op. cit., p. 51): Switzerland (S.) and the Tyrol (T.) (op. cit., p. 59).— **A. Diptera.** *Syrphidae*: 1. Cheilosia antiqua *Mg.* (S.); 2. Merodon cinereus *F.* (S.); 3. Syrphus confusus *Egg.* (?) (S.). **B. Hymenoptera.** *Apidae*: 4. Andrena proxima *K.* ♀ (T.). **C. Lepidoptera.** *Rhopalocera*: 5. Argynnis pales *S.-V.* (S.); 6. Colias phicomene *Esp.* (S.); 7. Erebia medea *S.-V.* (S.); 8. Melitaea parthenie *Bkh.* (S.): (Berlin Botanic Garden).—**A. Diptera.** *Syrphidae*: 1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. tenax *L.*; 4. Syrphus balteatus *Deg.*; 5. S. ribesii *L.* **B. Hemiptera.** 6. Strachia oleracea *L.* **C. Hymenoptera.** *Apidae*: 7. Halictus villosulus *K.* ♀, skg. **D. Lepidoptera.** *Rhopalocera*: 8. Pieris brassicae *L.*, skg.; 9. Vanessa urticae *L.*, do. Herm. Müller (Alps, L. hastilis, L. pyrenaeus, and other sp.), 6 beetles, 21 flies, 29 Hymenoptera, and 43 Lepidoptera ('Alpenblumen,' pp. 466–8). Scott-Elliot (Dumfriesshire), Apis, a humble-bee, and a Muscid ('Flora of Dumfriesshire,' p. 102).

1613. L. asper Poir.—

VISITORS.—Loew (Berlin Botanic Garden) observed a hover-fly (Syrphus ribesii *L.*) and 2 bees (Halictus villosulus *K.* ♀, po-cltg., and Heriades truncorum *L.* ♀, do.).

1614. L. crispus Vill.—

VISITORS.—Loew (Berlin Botanic Garden) observed 2 bees (Halictus villosulus *K.* ♀, po-cltg., and Psithyrus campestris *Pz.* ♂, skg.).

1615. L. pyrenaicus Gouan (?).—

VISITORS.—MacLeod observed a hover-fly and a Muscid in the Pyrenees.

490. Picris L.

Florets yellow. Sweeping-hairs and stigmatic papillae as in Leontodon.—

1616. P. hieracioides L. (Herm. Müller, 'Fertilisation,' pp. 352–3, 'Weit. Beob.,' III, p. 96.)—Hermann Müller states that in this species there are 44 to 75 florets in a head, and the marginal ones are larger than those in the centre. In sunny weather the capitulum spreads out into a golden-yellow disk 24–36 mm.

broad, but in dull weather it contracts to a diameter of 7 mm. As numerous inflorescences are associated on a stem about a metre in height, the plant is very conspicuous. The corolla-tube is 4–6 mm. and the ligule 8–12 mm. long. The anther-cylinder projects 5 mm. beyond the corolla-tube, and the style $2\frac{1}{2}$–$3\frac{1}{2}$ mm. further. *The stylar branches are 2 mm. long. When they diverge they often touch each other, thus effecting automatic self-pollination.*

VISITORS.—Herm. Müller (H. M.) in Westphalia and Buddeberg (Budd.) in Nassau observed the following.—

A. Diptera. (*a*) *Empidae*: 1. Empis livida *L.*, very numerous, skg. (Budd.). (*b*) *Syrphidae*: 2. Chrysogaster viduata *L.*, skg. and po-dvg. (H. M.); 3. Eristalis arbustorum *L.*, very common, do. (H. M.); 4. E. nemorum *L.*, do. (H. M.); 5. E. sepulcralis *L.*, do. (H. M.); 6. E. tenax *L.*, do. (H. M.); 7. Melithreptus scriptus *L.*, skg. and po-dvg. (H. M.); 8. M. taeniatus *Mg.*, do. (H. M.); 9. Syrphus balteatus *Deg.*, do. (H. M.). **B. Hymenoptera.** (*a*) *Apidae*: 10. Dasypoda hirtipes *F.* ♀ and ♂, skg. and po-cltg. (Budd.); 11. Halictus albipes *F.* ♂, skg. (H. M.); 12. H. cylindricus *F.* ♂, skg. (H. M., Budd.); 13. H. leucozonius *Schr.* ♀, skg. and po-cltg. (H. M.); 14. H. longulus *Sm.* ♀, do., ♂ skg. (H. M.); 15. H. maculatus *Sm.* ♀, do. (H. M., Budd.); 16. H. minutus *K.* ♀, do., ♂ skg. (H. M.); 17. H. nitidiusculus *K.* ♂, skg. (H. M.); 18. H. quadricinctus *F.* ♂, do. (H. M.); 19. H. rubicundus *Chr.* ♂, do. (H. M.); 20. H. sexnotatus *K.*, ♀ skg. and po-cltg., ♂ skg. (H. M.); 21. H. smeathmanellus *K.* ♀, do. (H. M.); 22. H. zonulus *Sm.* ♀, do. (H. M.); 23. Heriades truncorum *L.* ♀, po-cltg. (H. M.); 24. Osmia leucomelaena *K.* ♀, skg. (H. M., Thuringia); 25. O. spinulosa *K.* ♀, po-cltg. (H. M., Thuringia); 26. Panurgus calcaratus *Scop.* ♀ and ♂, freq., skg. and po-cltg. (H. M., Budd.); 27. Dufourea vulgaris *Schenck*, ♀ freq., ♂ scarce (H. M., Thuringia). (*b*) *Sphegidae*: 28. Crabro sexcinctus *F.* ♀ (H. M.). (*c*) *Vespidae*: 29. Vespa sylvestris *Scop.* ☿, pushing its head deep into the florets (H. M.). **C. Lepidoptera.** *Rhopalocera*: 30. Pieris brassicae *L.*, very common, skg. (H. M.); 31. P. rapae *L.*, do. (H. M.); 32. Epinephele janira *L.*, skg. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Loew (Berlin Botanic Garden), the butterfly Argynnis latonia *L.*, skg. the flowers. Friese, 7 bees in Baden (B.), Alsace (A.), Mecklenburg (M.), and Hungary (H.)—1. Andrena bimaculata *K.* (H.), 2nd gen., not infreq.; 2. Dasypoda plumipes *Pz.* (A.), freq.; 3. Dufourea vulgaris *Schenck* (B.), not infrequent (H.); 4. Eriades truncorum *L.* (M.), freq. (H.); 5. Osmia villosa *Schenck*, not infrequent (B.); 6. Panurgus banksianus *K.* (B.); 7. P. calcaratus *Scop.* (B.). Schenck (Nassau), 11 bees—1. Dasypoda plumipes *Pz.*; 2. Dufourea vulgaris *Schenck*; 3. Eriades truncorum *L.*; 4. Halictus albipes *F.* ♂; 5. H. levigatus *K.* ♂; 6. H. levis *K.*; 7. H. villosulus *K.* (=H. punctulatus *K.*); 8. Macropis labiata *F.*; 9. Panurgus calcaratus *Scop.*; 10. Stelis breviuscula *Nyl.*; 11. S. ornatula *Klug.*, a ♀. Schletterer (Tyrol), the bee Halictus albipes *F.* H. de Vries (Netherlands), 5 bees (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875)—1. Bombus agrorum *F.* ♂; 2. B. terrester *L.* ☿; 3. Halictus cylindricus *F.* ♂; 4. H. leucozonius *Schr.* ♂; 5. Osmia spinulosa *K.* ♀. MacLeod (Pyrenees), a humble-bee, 2 species of Panurgus, 2 beetles, and 3 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 366).

491. Helminthia Juss.

As Picris.

1617. H. echioides Gaertn.—According to Kirchner ('Beiträge,' pp. 71–2), the golden-yellow heads of this species spread out in the sun to form a disk 20 mm.

broad. Towards the end of anthesis the stylar branches roll back into a spiral of $1\frac{1}{2}$ to $1\frac{3}{4}$ turns, so that the papillose stigmatic surfaces easily come into contact with the pollen still clinging to the sweeping-hairs.

VISITORS.—Sprengel observed the honey-bee ('Entd. Geh.,' p. 367).

492. Tragopogon L.

Florets yellow in colour, more rarely violet; hermaphrodite and ligulate. Style with sweeping-hairs on its outer surface, and stigmatic papillae on the inner surfaces of its branches, which roll up at a later stage. Kerner states that the stylar branches of the outer florets roll back when they diverge, so as to come into contact with the pollen of the inner ones. The florets of the outer whorl are exactly opposite the spaces between the florets of the adjacent inner whorl, and this favours geitonogamy, for one of the stylar branches will touch the pollen-covered style of the floret on the right, while the other will touch the style of that on the left.

1618. T. pratensis L.—According to Kirchner ('Flora v. Stuttgart,' p. 737), the heads contain 20–50 golden-yellow florets, and when the weather is sunny they spread out in the forenoon to a diameter of 60 mm.; in the afternoon and during dull weather they are closed. Linnaeus states that they open 3–5 a.m. at Upsala, closing again between 8 and 10 a.m. The corolla-tube of the marginal florets is 6–7 mm. and the ligules as much as 30 mm. long. The central florets are smaller, with a corolla-tube of 5 mm. and a ligule of 7 mm. The stylar branches are 3 mm. long, and bend so far backwards that they make a spiral of several turns. Automatic self-pollination is thus effected if some pollen still clings to the sweeping-hairs. Warnstorf describes the pollen-grains as golden-yellow in colour, polyhedral, beset with spinose tubercles, up to 56 μ in diameter.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Knuth (Schleswig-Holstein).—**A. Coleoptera.** *Nitidulidae*: 1. Meligethes, freq., po-dvg. **B. Diptera.** (*a*) *Muscidae*: all po-dvg.: 2. Calliphora erythrocephala *Mg.*; 3. Scatophaga merdaria *F.* (*b*) *Syrphidae*: all po-dvg.: 4. Melithreptus taeniatus *Mg.*; 5. Syrphus balteatus *Deg.* **C. Hymenoptera.** *Apidae*: 6. Andrena sp., po-cltg.; 7. Bombus agrorum *F.*, skg.; 8. Halictus morio *F.*, po-cltg. **D. Lepidoptera.** *Rhopalocera*: 9. Pieris rapae *L.*, skg. Schiner (Austria), the Muscid Trypeta falcata *Scop.* Scott-Elliot (Dumfriesshire), a Muscid ('Flora of Dumfriesshire,' p. 102).

1619. T. orientalis L., and **1620. T. floccosus** Waldst. et Kit.—In these species, according to Kerner, the heads open between 6 and 7 a.m. at Innsbruck, closing again between 10 and 11 a.m.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Loew (Switzerland), on T. orientalis the Muscid Spilogaster angelicae *Scop.* ('Beiträge,' p. 60). Schletterer (Tyrol), the bee Halictus calceatus *Scop.* Loew (Berlin Botanic Garden), on T. floccosus.—**A. Diptera.** (*a*) *Muscidae*: 1. Anthomyia sp. (*b*) *Syrphidae*: 2. Eristalis nemorum *L.*; 3. E. tenax *L.*; 4. Syritta pipiens *L.*; 5. Syrphus balteatus *Deg.* **B. Hymenoptera.** (*a*) *Apidae*: 6. Halictus cylindricus *F.* ♀, po-cltg.; 7. Osmia fulviventris *Pz.* ♀, do. (*b*) *Vespidae*: 8. Odynerus parietum *L.*

1621. T. major Jacq.—

VISITORS.—Schiner saw the Muscid Trypeta falcata *Scop.* in Austria.

493. Urospermum Scop.

1622. U. Dalechampii F. W. Schmidt (=Tragopogon Dalechampii *L.*).—

VISITORS.—Schletterer observed the bee Halictus calceatus *Scop.* at Pola.

494. Scorzonera L.

Florets yellow in colour, more rarely lilac or rose-red. Structure of the style as in Tragopogon, and Kerner describes geitonogamy similar to what is found in that genus, the stylar branches of the outer florets diverging and rolling back so as to come into contact with the pollen of the inner ones.

1623. S. humilis L. (Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' p. 97.)—Should insect-visits fail, automatic self-pollination is possible by rolling back of the stylar branches.

VISITORS.—I observed the following visitors on garden plants in the Kiel Botanic Gardens ('Bloemenbiol. Bijdragen').

A. Coleoptera. *Nitidulidae*: 1. Meligethes, freq. **B. Diptera.** (*a*) *Muscidae*: 2. Lucilia cornica *F.*, po-dvg. (*b*) *Syrphidae*: 3. Eristalis tenax *L.*, po-dvg.; 4. Syrphus balteatus *Deg.*, do. **C. Hymenoptera.** *Apidae*: 5. Halictus cylindricus *F.*, skg.; 6. Panurgus sp., po-cltg. **D. Lepidoptera.** *Rhopalocera*: 7. Pieris brassicae *L.*, freq., skg.; 8. P. rapae *L.*, do.

1624. S. hispanica L.—

VISITORS.—Loew (Berlin Botanic Garden) observed a beetle (Anthaxia quadripunctata *L.*) and a bee (Osmia fulviventris *Pz.* ♀, po-cltg.), on the var. *glastifolia* Willd.

1625. S. parviflora Jacq.—

VISITORS.—Loew (Berlin Botanic Garden) observed a hover-fly (Eristalis nemorum *L.*) and 2 bees (Halictus cylindricus *F.* ♀, po-cltg., and Osmia fulviventris *Pz.* ♀, do.).

495. Hypochoeris L.

Florets yellow, and otherwise resembling those of Scorzonera, except that the stylar branches do not roll back so much. Kerner states that automatic self-pollination is brought about by gradual elongation of the ligules, the pollen adhering to which is thus brought into contact with the stigmas.

1626. H. radicata L. (Sprengel, 'Entd. Geh.,' pp. 369–70; Kirchner, 'Flora v. Stuttgart,' p. 739; Herm. Müller, 'Fertilisation,' p. 356, 'Weit. Beob.,' III, p. 97, 'Alpenblumen,' p. 469; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 97, 161–2, 'Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins.,' p. 237; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, v, 1893; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; Loew, 'Blütenbiol. Floristik,' p. 394.)—In this species the heads spread out in the forenoon in sunny weather to a diameter of 20–30 mm. Kirchner says that they contain from 50 to over 100 florets, with ligules 9–12 mm. in length. The

corolla-tube is 5–8 mm. long, and the anther-cylinder projects 4–5 mm. from it, while the style extends 5–6 mm. further. The stylar branches are 1 mm. long and do not curve far enough back to render automatic self-pollination possible. Bees belonging to species of Panurgus are particularly common visitors.

VISITORS.—Knuth observed the following in the North Frisian Islands.—

A. Diptera. (*a*) *Empidae*: 1. Empis livida *L.*, skg. (*b*) *Muscidae*: 2. Anthomyia sp. ♀; 3. Coenosia sp.; 4. Trypeta sp.; 5. One small Muscid. (*c*) *Syrphidae*: all skg. and po-dvg.: 6. Chrysotoxum festivum *L.*; 7. Eristalis arbustorum *L.*; 8. E. tenax *L.*; 9. Helophilus pendulus *L.* **B. Hymenoptera.** *Apidae*: all po-cltg. and skg.: 10. Apis mellifica *L.*; 11. Colletes daviesanus *K.*; 12. Dasypoda plumipes *Ltr.*; 13. Panurgus ater *Ltr.*; 14. P. lobatus *F.* **C. Lepidoptera.** *Rhopalocera*: all skg.: 15. Coenonympha pamphilus *L.*; 16. Epinephele janira *L.*; 17. Polyommatus phlaeas *L.*

Alfken observed the following bees at Bremen.—

1. Andrena albicrus *K.* ♀; 2. A. humilis *Imh.* ♀; 3. A. tarsata *Nyl.* ♀; 4. Bombus lapidarius *L.* ☿; 5. Dasypoda plumipes *Pz.* ♀ and ♂; 6. Dufourea vulgaris *Schenck* ♀ and ♂; 7. Eriades florisomnis *L.* ♂; 8. E. truncorum *L.* ♀; 9. Halictus calceatus *Scop.* ♀; 10. H. leucozonius *Schr.* ♀; 11. H. morio *F.* ♀ and ♂; 12. H. nitidiusculus *K.* ♀; 13. H. punctulatus *K.* ♀; 14. H. tomentosus *Schenck* ♀; 15. H. tumulorum *L.* ♀; 16. H. zonulus *Sm.* ♀; 17. Megachile centuncularis *K.* ♂ and ♀; 18. Nomada brevicornis *Mocs.* ♀; 19. Nomada fuscicornis *Nyl.* ♀; 20. Osmia solskyi *Mor.* ♀; 21. Panurgus banksianus *K.* ♀ and ♂; 22. P. calcaratus *Scop.* ♀ and ♂; 23. Prosopis communis *Nyl.* ♂; 24. P. confusa *Nyl.* ♀.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Diptera. (*a*) *Conopidae*: 1. Sicus ferrugineus *L.*, skg. (H. M.). (*b*) *Muscidae*: 2. Demoticus plebeius *Fall.*, skg. (H. M.); 3. Ocyptera brassicariae *F.*, do. (Budd.). (*c*) *Syrphidae*: 4. Eristalis arbustorum *L.* (H. M.); 5. E. nemorum *L.* (H. M.); 6. E. sepulcralis *L.*, po-dvg. (H. M.); 7. Pipiza funebris *Mg.*, po-dvg. (Budd.). **B. Hymenoptera.** (*a*) *Apidae*: 8. Andrena denticulata *K.* ♀ and ♂, po-cltg. and skg. (H. M., Thuringia, Borgstette); 9. A. fulvago *Chr.* ♀, po-cltg. (H. M., Thuringia); 10. A. fulvescens *Sm.* ♀, skg. and po-cltg. (H. M., Thuringia and the Bavarian Oberpfalz); 11. A. xanthura *K.* ♀, skg. (H. M., Budd.); 12. Apis mellifica *L.* ☿, po-cltg. (H. M.); 13. Bombus lapidarius *L.* ☿, skg. (H. M.); 14. Colletes daviesanus *K.* ♀ and ♂, numerous, po-cltg. and skg. (H. M.); 15. Dasypoda hirtipes *F.* ♀, freq., po-cltg. (H. M., Budd.); 16. Diphysis serratulae *Pz.* ♂, skg. (H. M.); 17. Halictus brevicornis *Schenck* ♂, do. (H. M.); 18. H. cylindricus *F.* ♀ and ♂, po-cltg. and skg. (H. M.); 19. H. flavipes *F.* ♂ (H. M.); 20. H. leucozonius *Schr.* ♀ and ♂, po-cltg. and skg. (H. M.); 21. H. lugubris *K.* ♂ (H. M.); 22. H. malachurus *K.* ♀, po-cltg. (H. M.); 23. H. quadricinctus *F.* ♀, skg. and po-cltg. (Budd.); 24. H. rubicundus *Chr.* ♀, po-cltg. (H. M.); 25. H. sexcinctus *F.* ♀, skg. and po-cltg. (Budd.); 26. H. sexstrigatus *Schenck* ♀, po-cltg. (H. M.); 27. H. villosulus *K.* ♀, do. (H. M.); 28. Panurgus banksianus *K.* ♀ and ♂, skg. and po-cltg. (H. M.); 29. P. calcaratus *Scop.* ♀ and ♂, freq., skg. and po-cltg. (H. M., Budd.); 30. Dufourea vulgaris *Schenck* ♀, skg. and po-cltg. (H. M.); 31. Sphecodes gibbus *L.* ♀ and ♂ (H. M.). (*b*) *Sphegidae*: 32. Lindenius albilabris *F.*, skg. (Budd.). **C. Lepidoptera.** *Rhopalocera*: 33. Rhodocera rhamni *L.*, skg. (H. M., Fichtelgebirge).

Loew observed the following.—

In Silesia ('Beiträge,' p. 31).—**A. Coleoptera.** (*a*) *Chrysomelidae*: 1. Cryptocephalus hypochoeridis *L.* ♀ and ♂. (*b*) *Oedemeridae*: 2. Oedemera flavipes *F.* ♂; 3. Q. virescens *L.* **B. Diptera.** *Syrphidae*: 4. Cheilosia sp., po-dvg.; 5. Meli-

threptus scriptus *L.*; 6. Syrphus balteatus *Deg.* **C. Hymenoptera.** *Apidae*: 7. Andrena nana *K.* ♀, po-cltg.; 8. Diphysis serratulae *Pz.* ♀, do.; 9. Halictus cylindricus *F.* ♀, do.; 10. H. leucozonius *Schr.* ♀, do. **D. Lepidoptera.** *Rhopalocera*: 11. Vanessa urticae *L.*, skg. Also in Silesia (S.), especially at Glatz (G.) (op. cit., p. 50).—**A. Diptera.** (*a*) *Bibionidae*: 1. Bibio pomonae *F.* (S.). (*b*) *Syrphidae*: 2. Cheilosia variabilis *Pz.* (S.). **B. Hymenoptera.** *Apidae*: 3. Andrena convexiuscula *K.* ♀, po-cltg. (S.); 4. A. fulvescens *Sm.* ♀, do. (S.); 5. Dufourea vulgaris *Schenck* ♀ and ♂ skg., ♀ also po-cltg. (G.); 6. Halictus flavipes *F.* ♀, po-cltg. (S.); 7. H. malachurus *K.* ♀ (S.); 8. H. punctulatus *K.* ♀ (S.); 9. H. smeathmanellus *K.* ♀ (S.); 10. H. xanthopus *K.* ♀, po-cltg. (S.); 11. Panurgus banksianus *K.* ♀ and ♂, skg., po-cltg. (S.); 12. Prosopis sp. (S.).

The following were recorded by the observers, and for the localities stated.—

A. Diptera. (*a*) *Muscidae*: 1. Onesia floralis *R.-D.* (*b*) *Syrphidae*: 2. Chrysogaster sp., occasional; 3. Platycheirus albimanus *F.* ♀; 4. Syrphus corollae *F.* ♀ and ♂. **B. Hymenoptera.** *Apidae*: 5. Bombus lapidarius *L.* ☿ and ♂, freq., skg. Alfken (Juist), the humble-bee Bombus muscorum *F.* ☿. Krieger (Leipzig), the bees Halictus rubicundus *Chr.* and Panurgus banksianus *K.* Herm. Müller (Alps), 4 bees, 2 hover-flies, and a beetle. MacLeod (Flanders), 9 short-tongued bees (among them 2 species of Panurgus), 8 hover-flies, 4 Muscids, and 3 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 430–1): (Pyrenees), 7 bees (among them 2 species of Panurgus), 5 beetles, 5 Lepidoptera, and 11 flies (op. cit., iii, 1891, pp. 364–5). Scott-Elliot (Dumfriesshire), 2 Muscids ('Flora of Dumfriesshire,' p. 103).

1627. H. glabra L. (Herm. Müller, 'Fertilisation,' p. 356.)—

Visitors.—*The following were recorded by the observers, and for the localities stated.*—

Herm. Müller (Westphalia), 5 bees—1. Andrena fulvescens *Sm.* ♀, po-cltg.; 2. Dufourea vulgaris *Schenck* ♀, po-cltg. and skg.; 3. Halictus cylindricus *F.* ♀, po-cltg.; 4. H. nitidiusculus *K.* ♀ (Borgstette, Tecklenburg); 5. Sphecodes gibbus *L.* ♀ and ♂, skg. and covering itself with pollen. H. de Vries (Netherlands), the humble-bee Bombus subterraneus *L.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875).

496. Achyrophorus Adans.

As Hypochoeris.

1628. A. maculatus Scop. (=Hypochoeris maculata *L.*).—Linnaeus says that the heads of this species open at 6 a.m. at Upsala, and close between 4 and 5 p.m.; according to Kerner, they open between 7 and 8 a.m. at Innsbruck, closing again about 6 or 7 p.m.

Visitors.—Loew (Berlin Botanic Garden) observed the bee Osmia fulviventris *Pz.* ♀, po-cltg.

1629. A. uniflorus F. W. Schmidt (=Hypochoeris helvetica *Wulf.*, and Hypochoeris uniflora *Vill.*).—In this species, according to Hermann Müller ('Alpenblumen,' p. 468), the stylar branches bend gradually so far outwards and backwards that the stigmatic papillae on their inner surfaces come into contact with any pollen that may have remained among the sweeping-hairs, so that in the absence of insect visitors automatic self-pollination may be effected.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 3 beetles, 2 flies, 4 bees, and **14** **Lepidoptera**. Loew (Alps), the hawk-moth Zygaena exulens *Hochw. et Rein*: (Altvatergebirge), 11 hover-flies, skg. — 1. Cheilosia **canicularis** *Pz.*; 2. C. sp.; 3. Didea intermedia *Loew*; 4. **Platycheirus** manicatus *Mg.*; 5. Sericomyia borealis *Fall.*; 6. Syrphus **annulipes** *Zett.*; 7. S. cinctellus *Zett.*; 8. S. corollae *F.*; 9. S. lunulatus *Mg.*; 10. S. pyrastri *L.*; 11. S. topiarius *Mg.*

497. Taraxacum L.

Florets yellow. Style covered externally with sweeping-hairs that extend considerably below the cleft, and are directed obliquely upwards; stylar branches beset with stigmatic papillae internally, and rolling up to a marked degree. Kerner says that in the outer florets these branches diverge and roll back to such an extent that they come into contact with the pollen of the inner ones.

Among the species native to Denmark, Raunkjær (Bot. Tids., Kjöbenhavn, xxv, 1903, pp. 109–40) found some plants in which the anthers were always devoid of pollen, and which were therefore purely female (T. paludosum *Scop.*, T. Ostenfeldii *Raunkj.*, T. speciosum *Raunkj.*, and T. decipiens *Raunkj.*). He cut off with a razor the upper half of an unopened capitulum of such a plant, leaving only the lower part of the corolla-tubes, filaments, and styles, together with the ovaries. In spite of this severe treatment the last developed into perfect fruits. The same experiment was tried with the same result in hermaphrodite species (T. vulgare *Lam.*, T. intermedium *Raunkj.*, and T. Gelertii *Raunkj.*), including the S. European form T. obovatum *DC.*, and the Pamir species T. glaucanthum *DC.* As in these cases no germinating pollen-grains could be found on the stigmas, Raunkjær regarded the species named as parthenogenetic.

1630. T. officinale Wigg. (=Leontodon Taraxacum *L.*). (Hildebrand, 'Ü. d. Geschlechtsverhält. b. d. Compositen,' pp. 7–13, Taf. I, Figs. 1–7; Herm. Müller, 'Fertilisation,' pp. 359–61, 'Weit. Beob.,' III, pp. 94–5, 'Alpenblumen,' p. 464; Loew, 'Blütenbiol. Floristik,' pp. 390, 394, 398; Lindman, 'Bidrag till Känned. om Skandin. Fjellväxt. Blomn. o. Befrukt.'; Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II, pp. 217–18, 319; H. de Vries, Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, v, 1893; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 97–8, 162, 'Bl. u. Insekt. a. Helgoland'; Warnstorf, Verh. bot. Ver., Berlin, xxxviii, 1896, xxxix, 1897, xl, 1897; Benecke, Ber. D. bot. Ges., Berlin, ii, 1884, p. 192.)—In this species the yellow capitula are 30–50 mm. broad when expanded in the sunshine: on the Dovrefjeld Lindman observed abnormally large inflorescences of a bright yellow-red colour, with a diameter of as much as 60 mm., and possessing greatly enlarged marginal florets. At night and during dull weather the heads remain closed. Linnaeus says that they open at 5–6 a.m. at Upsala, closing again as early as 8–10 a.m. At Innsbruck, according to Kerner, they open at 6–7 a.m., and close at 2–3 p.m. Benecke states that when the heads open, the outer involucral bracts first fold back as a result of the more vigorous growth of their inner surfaces. The inner involucral bracts are only passively turned outwards by the opening of the florets, and this holds for the first expansion of the head, as well as for every time it subsequently opens during the morning; in the evening these bracts close in again owing to their elasticity.

Hermann Müller states that a head consists of 100–200 florets with corolla-tubes 3–7 mm. and ligules 7–15 mm. in length. The anther-cylinder projects $2\frac{1}{2}$–5 mm. from the corolla-tube, and the style extends 3–5 mm. further. In the second stage of anthesis, the stylar branches, which are $1\frac{1}{2}$–2 mm. long, bend outwards and roll back so far as to form a spiral of $1\frac{1}{2}$ turns. If, therefore, the pollen has not all been removed by insect visitors, automatic self-pollination necessarily takes place. According to Kerner, automatic geitonogamy also takes place, the stylar branches of the outer florets diverging and rolling back so as to come into contact with the pollen of the inner ones. Hansgirg also observed pseudo-cleistogamous florets. Warnstorf describes the pollen-grains as golden-yellow in colour, polyhedral, spinose, about 37 μ in diameter.

VISITORS.—Alfken observed the following at Bremen.—

A. Diptera. (*a*) *Bibionidae*: 1. Bibio marci *L.*, not infrequent. (*b*) *Empidae*: 2. Empis ciliata *L.*, freq.; 3. E. opaca *F.*, excessively freq., skg. (*c*) *Syrphidae*: 4. Eristalis arbustorum *L.*, freq., skg.; 5. E. intricarius *L.*, do.; 6. E. pertinax *Scop.*, do.; 7. E. sepulcralis *L.*, not infrequent, skg.; 8. E. tenax *L.*, very common, skg.; 9. Helophilus pendulus *L.*, do.; 10. Leucozona lucorum *L.*, rare, skg.; 11. Sericomyia borealis *Fall.*, freq., skg.; 12. Spilomyia vespiformis *L.*, very rare; 13. Syrphus tricinctus *Fall.*, skg.; 14. S. venustus *Mg.*, very common, skg. **B. Hymenoptera.** (*a*) *Apidae*: 15. Andrena albicans *Müll.*, very common, ♀ skg. and po-cltg., ♂ skg. This is the commonest pollinator: with obvious satisfaction it lies on its side and probes the inflorescence. 16. A. albicrus *K.* ♀ and ♂, not infrequent; 17. A. apicata *Sm.* ♀ and ♂, rare, it chiefly visits willows; 18. A. argentata *Sm.* ♀, rare; 19. A. carbonaria *L.*, ♀ and ♂, do.; 20. A. chrysosceles *K.* ♀ and ♂, do.; 21. A. cineraria *L.* ♀, freq., skg. and po-cltg., ♂ very common, skg.; 22. A. cingulata *F.* ♀ and ♂, very rare; 23. A. convexiuscula *K.* ♀ and ♂, rare; 24. A. dorsata *K.* ♂, once; 25. A. extricata *Sm.* ♀ not infrequent, skg. and po-cltg., ♂ very common, skg.; 26. A. flavipes *Pz.* ♀ extremely freq., skg. and po-cltg., ♂ do., skg.; 27. A. fucata *Sm.* ♀, very rare; 28. A. fulvaga *Chr.* ♂; 29. A. gwynana *K.* ♀ not infrequent, skg. and po-cltg., ♂ not infrequent, skg.; 30. A. helvola *L.* ♀ and ♂, very rare; 31. A. humilis *Imh.* ♀ and ♂, mostly stylopized individuals; 32. A. labialis *K.* ♀ and ♂, rare; 33. A. labiata *Schenck* ♀, very rare, skg. and po-cltg.; 34. A. morawitzi *Ths.* ♀ and ♂, not infrequent; 35. A. nigroaenea *K.* ♀ very common, skg. and po-cltg., ♂ very common, skg.; 36. A. nitida *Fourcr.* ♀ very common, skg. and po-cltg., ♂ very common, skg.; 37. A. ovina *Klg.* ♀ infrequent, skg. and po-cltg., ♂ rare, skg.; 38. A. parvula *K.* ♀ very common, skg. and po-cltg., ♂ not frequent, skg.; 39. A. praecox *Scop.* ♀, not freq., skg. and po-cltg., chiefly visits willows, ♂ rare; 40. A. propinqua *Schenck*; 41. A. proxima *K.* ♀ and ♂, rare; 42. A. rufitarsis *Zett.* ♀ freq., skg. and po-cltg., ♂ very rare; 43. A. thoracica *F.* ♀ rare, skg. and po-cltg., ♂ rare, skg.; 44. A. tibialis *K.*, rare, ♀ skg. and po-cltg., ♂ skg.; 45. A. trimmerana *K.*, do., ♀ do., ♂ do.; 46. A. varians *K.* ♀ and ♂, rare; 47. Bombus agrorum *F.* ♀, not infreq., skg. and po-cltg.; 48. B. arenicola *Ths.* ♀, rare; 49. B. derhamellus *K.* ♀, freq., skg. and po-cltg.; 50. B. distinguendus *Mor.* ♀, not infreq., skg. and po-cltg.; 51. B. hortorum *L.* ♀ rare, ♂ rare, skg. in plants flowering in autumn; 52. B. jonellus *K.* ♀, rare, skg. and po-cltg., a characteristic visitor of willows; 53. B. lapidarius *L.* ♀, very common, skg. and po-cltg.; 54. B. lucorum *L.* ♀, do.; 55. B. muscorum *F.* ♀ and ☿, not infreq., skg. and po-cltg.; 56. B. pratorum *L.* ♀, skg.; 57. B. ruderatus *F.* ♀, rare, skg. and po-cltg.; 58. B. sylvarum *L.* ♀, not infreq., skg. and po-cltg.; 59. B. terrester *L.*, very common, skg. and po-cltg.; 60. Colletes cunicularius *L.* ♀, rare, po-cltg.; 61. Eriades florisomnis *L.* ♀ and ♂; 62. Eucera difficilis (*Duf.*) *Pér.* ♂; 63. Halictus calceatus *Scop.*, and var. elegans *Lep.* ♀, rare, skg. and po-cltg.; 64. H. flavipes *F.* ♀, freq., skg. and po-cltg.; 65. H. levis *K.* ♀, not infrequent, skg. and po-cltg.; 66. H. malachurus *K.*, very rare;

67. H. morio *F.* ♀, not infrequent, skg. and po-cltg.; 68. H. nitidiusculus *K.* ♀, very common, do.; 69. H. punctatissimus *Schenck* ♀, freq., do.; 70. H. punctulatus *K.* ♀, very common, do.; 71. H. quadrinotatus *K.* ♀, very rare; 72. H. quadrinotatulus *Schenck*, once; 73. H. rubicundus *Chr.* ♀, very common, skg. and po-cltg., the spring females confine their visits almost exclusively to this species; 74. H. sexnotatulus *Nyl.* ♀, rare, skg. and po-cltg.; 75. H. zonulus *Sm.* ♀, do.; 76. Melecta armata *Pz.* ♀, rare, skg.; 77. Nomada alternata *K.* ♀ and ♂, freq., skg.; 78. N. bifida *Ths.* ♀ and ♂, very freq., skg.; 79. N. borealis *Zett.* ♀ and ♂, not infrequent, skg.; 80. N. fabriciana *L.* ♀ and ♂, very rare; 81. N. flavoguttata *K.* ♀ and ♂, not infrequent, skg.; 82. N fucata *Pz.* ♀ and ♂, not infrequent, skg.; 83. N. lathburiana *K.* ♀ and ♂, rare, skg.; 84. N. lineola *Pz.* ♀ and ♂, rare, skg.; 85. N. ruficornis *L.* ♀ and ♂, do.; 86. N. succincta *L.* ♀ and ♂, freq., skg.; 87. N. xanthosticta *K.* ♀ and ♂, rare, skg.; 88. Osmia caerulescens *L.* ♀ and ♂, rare; 89. O. rufa *L.* ♀ and ♂, rare; 90. O. solskyi *Mor.*, not infrequent, skg.; 91. Podalirius acervorum *L.* ♀, once; 92. Psithyrus barbutellus *K.* ♀, freq., skg.; 93. P. campestris *Pz.* ♀, do.; 94. P. quadricolor *Lep.* ♀, once; 95. P. rupestris *F.* ♀, not infreq., skg.; 96. P. vestalis *Fourcr.* ♀, very common, skg. (*b*) *Tenthredinidae*: 97. Dolerus pratensis *Fall.*; 98. Emphytus cinctus *L.*; 99. Pachyprotasis rapae *L.* (*c*) *Vespidae*: 100. Odynerus callosus *Ths.*

Friese observed the following bees in Alsace (A.), Baden (B.), Hungary (H.), and Mecklenburg (M.); also at Fiume (F.) and Trieste (T.).—

1. Andrena albicans *Müll.* (M.), not infreq.; 2. A. carbonaria *L.* (M.), do.; 3. A. cineraria *L.*, 1st gen., not infreq. (M.), 2nd gen., 1 ♀ (H.); 4. A. extricata *Sm.* (M.), not infreq.; 5. A. flavipes *Pz.* (M.), freq. (B., A.); 6. A. fucata *Pz.*, not infreq. (A.); 7. A. gwynana *K.*, freq. (M.); 8. A. humilis *Imh.*, freq. (T., H.); 9. A. taraxaci *Gir.*, freq. (T., H.); 10. A. tibialis *K.*, freq. (M.); 11. A. thoracica *F.*, 1 ♀, (A.); 12. Halictus rubicundus *Chr.*, freq. (M.); 13. H. xanthopus *K.*, occasional (M.); 14. Nomada lathburiana *K.*, occasional (M.); 15. N. succincta *Pz.*, freq. (M.); 16. N. trispinosa *Schmiedekn.*, freq. (H.); 17. N. zonata *Pz.* (F., H.); 18. Osmia rufohirta *Lep.* ♀, freq., po-cltg. (H.): also in Thuringia—1. Andrena cineraria *L.*; 2. Halictus rufocinctus (*Sich.*) *Nyl.*; 3. H. xanthopus *K.*

Loew observed the following.—

In Brandenburg ('Beiträge,' p. 40).—**A. Coleoptera.** (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (*b*) *Nitidulidae*: 2. Meligethes sp. **B. Diptera.** (*a*) *Stratiomyidae*: 3. Cheilosia praecox *Zett.*; 4. Helophilus pendulus *L.* **C. Hymenoptera.** *Apidae*: 5. Andrena albicans *Müll.* ♀, po-cltg.; 6. A. albicrus *K.* ♀, do.; 7. A. cineraria *L.* ♀, do.; 8. A. combinata *Chr.* ♀, do.; 9. A. nigroaenea *K.* ♀, do.; 10. A. pilipes *F.* ♀; 11. A. ventralis *Imh.* ♀, po-cltg.; 12. Chelostoma maxillosum *L.* ♂, skg.; 13. Dasypoda hirtipes *F.* ♀, po-cltg.; 14. Halictus cylindricus *F.* ♀, skg.; 15. H. levis *K.* ♀, po-cltg.; 16. H. maculatus *Sm.* ♀, po-cltg.; 17. H. minutus *K.* ♀, do.; 18. H. punctulatus *K.* ♀, do.; 19. H. quadristrigatus *Ltr.* ♀ and ♂, skg., ♀ also po-cltg.; 20. H. sexcinctus *F.* ♂, skg.; 21. Nomada fucata *Pz.* ♂, do.; 22. Sphecodes gibbus *L.*, do.; 23. Trypetes truncorum *L.* ♀, po-cltg. In Hesse (op. cit., p. 51).—Andrena chrysosceles *K.* ♀, po-cltg. In Switzerland (op. cit., p. 59).—**A. Coleoptera.** *Chrysomelidae*: 1. Cryptocephalus hypochoeridis *L.* **B. Diptera.** *Syrphidae*: 2. Cheilosia canicularis *Pz.*; 3. C. plumulifera *Loew* (?); 4. Eristalis nemorum *L.*; 5. Merodon cinereus *F.*; 6. Syrphus lineola *Zett.*; 7. S. vittiger *Zett.* (?); 8. Xylota triangularis *Zett.* **C. Hymenoptera.** *Tenthredinidae*: 9. Tarpa spissicornis *Klg.*

Burkill observed the following on the Yorkshire coast ('Fertlsn. of Spring Fls.').—

A. Coleoptera. (*a*) *Curculionidae*: 1. Apion sp. (*b*) *Nitidulidae*: 2. Meligethes picipes *Sturm*, skg. and po-dvg. **B. Diptera.** (*a*) *Bibionidae*: 3. Dilophus albipennis *Mg.*, po-dvg. (*b*) *Muscidae*: 4. Calliphora erythrocephala *Mg.*; 5. Helomyza sp., skg.; 6. Lucilia cornicina *F.*, do.; 7. Scatophaga stercoraria *L.*, skg. and po-dvg.;

8. Sepsis nigripes *Mg.*; skg.; 9. Stomoxys sp., po-dvg. (*c*) *Syrphidae*: 10. Eristalis arbustorum *L.*, skg.; 11. E. pertinax *Scop.*, do. **C. Hymenoptera.** (*a*) *Apidae*: 12. Andrena clarkella *K.*; 13. A. gwynana *K.*, skg.; 14. Apis mellifica *L.*, rare, skg.; 15. Bombus agrorum *F.*, skg.; 16. B. terrester *L.*, do.; 17. Nomada borealis *Zett.*, once, skg. (*b*) *Ichneumonidae*: 18. Ichneumon sp., skg. **D. Lepidoptera.** *Rhopalocera*: 19. Pieris rapae *L.*, do., skg.; 20. Vanessa urticae *L.*, do. **E. Thysanoptera.** 21. Thrips sp.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (H. M.). (*b*) *Chrysomelidae*: 2. Gastrophysa polygoni *L. in copula* on the flowers (H. M.). (*c*) *Coccinellidae*: 3. Coccinella septempunctata *L.*, vainly trying to suck (H. M.). (*d*) *Elateridae*: 4. Corymbites haematodes *F.*, sinking its head deeply into the florets (H. M.); 5. Limonius cylindricus *Payk.*, do. (H. M.). (*e*) *Nitidulidae*: 6. Meligethes, in extremely large numbers in the florets (H. M.). (*f*) *Telephoridae*: 7. Malachius bipustulatus *L.*, po-dvg. (H. M.); 8. M. elegans *Oliv.* ♂, do. (H. M.). **B. Diptera.** (*a*) *Empidae*: 9. Empis livida *L.*, freq., skg. (H. M.); 10. E. opaca *F.*, skg. (H. M.); 11. E. punctata *F.*, in large numbers, skg. (H. M.). (*b*) *Muscidae*: 12. Cyrtoneura hortorum *Fall.* ♀, skg. and po-dvg. (H. M.); 13. Onesia floralis *R.-D.*, freq. (H. M.); 14. Pollenia vespillo *F.*, po-dvg. (H. M.); 15. Sarcophaga carnaria *L.*, do. (H. M.); 16. Scatophaga merdaria *F.*, freq., skg. and po-dvg. (H. M.); 17. S. stercoraria *L.*, do. (H. M.). (*c*) *Syrphidae*: 18. Ascia lanceolata *Mg.*, skg. (H. M.); 19. A. podagrica *F.*, freq., po-dvg. (H. M.); 20. Cheilosia chloris *Mg.*, po-dvg. (H. M.); 21. C. vernalis *Fall.*, do. (H. M.); 22. Eristalis arbustorum *L.*, freq., skg. and po-dvg. (H. M.); 23. E. intricarius *L.*, do. (H. M.); 24. E. nemorum *L.*, do. (H. M.); 25. E. pertinax *Scop.*, do. (H. M.); 26. E. sepulcralis *L.*, do. (H. M.); 27. E. tenax *L.*, do. (H. M.); 28. Melithreptus menthastri *L.*, po-dvg. (H. M.); 29. M. taeniatus *Mg.*, do. (H. M.); 30. Rhingia rostrata *L.* (H. M.); 31. Syrphus nitidicollis *Mg.*, po-dvg. (H. M.); 32. S. pyrastri *L.*, do. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 33. Andrena albicans *Müll.* ♀, skg. and po-dvg., ♂ (H. M.); 34. A. albicrus *K.*, do. (H. M.); 35. A. argentata *Sm.* ♂, freq., skg. (H. M.); 36. A. atriceps *K.* ♀ skg. and po-cltg., ♂ skg. (H. M.); 37. A. cineraria *L.*, do. (H. M.); 38. A. cingulata *K.* ♂, skg. (H. M.); 39. A. connectens *K.* ♀, skg. and po-cltg. (H. M.); 40. A. convexiuscula *K.* ♀, do. (H. M.); 41. A. dorsata *K.* ♀ do., ♂ skg. (H. M.); 42. A. fasciata *Wesm.*, do. (H. M.); 43. A. flavipes *Pz.*, very common, ♀ skg. and po-cltg., ♂ skg. (H. M.); 44. A. fulva *Schr.* ♀, skg. and po-cltg. (H. M.); 45. A. fulvescens *Sm.* ♀, do. (H. M.); 46. A. gwynana *K.*, do. (H. M.); 47. A. helvola *L.*, do. (H. M.); 48. A. mixta *Schenck* ♀, skg. and po-cltg. (a var. of 47) (H. M.); 49. A. nigroaenea *K.* ♀, skg. and po-cltg. (H. M.); 50. A. nitida *Fourcr.* ♀ do., ♂ skg. (H. M.); 51. A. parvula *K.*, do., freq. (H.M.); 52. A. pratensis *Nyl.* ♀, skg. and po-cltg. (H. M.); 53. A. smithella *K.* ♀ do., ♂ skg. (H. M.); 54. A. trimmerana *K.* ♀, do. (H. M.); 55. A. varians *K.* ♀, do., not infreq. (H. M.); 56. Apis mellifica *L.* ☿, very numerous, skg. and po-cltg. (H. M.); 57. Bombus agrorum *F.* ♀, skg. (H. M.); 58. B. confusus *Schenck* ♀, do. (H. M.); 59. B. lapidarius *L.* ♀, do. (H. M.); 60. B. sylvarum *L.* ♀, do. (H. M.); 61. B. terrester *L.* ♀, do. (H. M.); 62. Halictus albipes *F.* ♀, freq., skg. and po-cltg. (H. M.); 63. H. cylindricus *F.* ♀, do. (H. M.); 64. H. flavipes *F.* ♀, skg. and po-cltg. (H. M.); 65. H. leucopus *K.* ♀, do. (H. M.); 66. H. leucozonius *Schr.* ♀, freq., do. (Budd.); 67. H. longulus *Sm.* ♀, skg. and po-cltg. (H. M.); 68. H. lucidulus *Schenck* ♀, do. (H. M.); 69. H. maculatus *Sm.*, ♀, do. (H. M.); 70. H. malachurus *K.* ♀, skg. (H. M.); 71. H. minutissimus *K.* ♀, skg. and po-cltg. (H. M.); 72. H. morio *F.* ♀, do. (H. M.); 73. H. nitidiusculus *K.* ♀, freq., do. (H. M.); 74. H. nitidus *Schenck* ♀, skg. and po-cltg. (H. M.); 75. H. rubicundus *Chr.* ♀, do. (H. M.); 76. H. sexnotatus *K.* ♀, freq., do. (H. M.); 77. H. sexsignatus *Schenck* ♀, do. (H. M.); 78. H. smeathmanellus *K.* ♀, occasional,

skg. and po-cltg. (Budd.); 79. H. villosolus *K.* ♀, skg. and po-cltg. (H. M.); 80. H. zonulus *Sm.* ♀, do. (H. M.); 81. Megachile centuncularis *L.* ♂, skg. (Budd.); 82. Nomada alternata *K.* ♀, do. (H. M.); 83. N. flavoguttata *K.* ♂, do. (H. M.); 84. N. lathburiana *K.* ♀, do. (H. M.); 85. N. lineola *Pz.* ♀, do. (H. M.); 86. N. ruficornis *L.* ♀ and ♂, very numerous, skg. (H. M.); 87. N. ruficornis *L.*, var. signata *Jur.* ♀ and ♂, skg. (H. M.); 88. N. succincta *Pz.* ♀ and ♂, do. (H. M.); 89. N. varia *Pz.* ♀ and ♂, freq., skg. (H. M.); 90. Osmia aenea *L.* ♂, skg. (Budd.); 91. O. aurulenta *Pz.* ♀, do. (H. M., Thür.); 92. O. fusca *Chr.* ♀, po-cltg. (H. M.); 93. O rufa *L.* ♂, skg. (H. M.); 94. Psithyrus barbutellus *K.* ♀, do. (H. M.); 95. B. vestalis *Fourcr.* ♀, do. (H. M.); 96. Sphecodes gibbus *L.* ♀, skg. and po-cltg. (H. M.); 97. Stelis aterrima *Pz.* ♂, skg. (Budd.); 98. S. minuta *Lep.* ♂, do. (Budd.). (*b*) *Formicidae*: 99. Formica congerens *Nyl.* ☿, freq., skg. (H. M.); 100. Lasius niger *L.* ☿, freq. (H. M.). (*c*) *Sphegidae*: 101. Oxybelus uniglumis *L.*, probing the florets deeply (H. M.). (*d*) *Tenthredinidae*: 102. Cephus pallidipes *Klg.* (Budd.); 103. C., a small sp., numerous (H. M.). (*e*) *Vespidae*: 104. Odynerus parietum *L.* ♂ (H. M.). **D. Hemiptera.** 105. Pyrrhocoris apterus *L.*, freq., skg. (H. M.). **E. Lepidoptera.** *Rhopalocera*: all skg.: 106. Parage megaera *L.* (H. M.); 107. Pieris brassicae *L.* (H. M.); 108. P. napi *L.* (H. M.); 109. Rhodocera rhamni *L.* (H. M.); 110. Syrichthus alveolus *Hb.* (H. M.); 111. Vanessa io *L.*, freq. (H. M.); 112. V. urticae *L.*, freq. (H. M.). **F. Thysanoptera.** 113. Thrips, freq. (H. M.).

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands), Apis, 3 humble-bees, 8 hover-flies, 2 Muscids, 4 Lepidoptera, and the beetle Meligethes: (Helgoland).—**A. Coleoptera.** *Telephoridae*: 1. Psilotrix cyanea *Ol.*, very common. **B. Diptera.** (*a*) *Muscidae*: skg. and po-dvg.: 2. Coelopa frigida *Fall.*, very common; 3. Lucilia caesar *L.*, common; 4. Scatophaga stercoraria *L.*, freq. (*b*) *Syrphidae*: 5. Helophilus pendulus *L.*, one ♀, skg. and po-dvg. **C. Lepidoptera.** *Rhopalocera*: 6. Pieris brassicae *L.*, occasional, skg. **D. Hymenoptera.** *Apidae*: 7. Andrena labialis *K.* ♀, skg.; 8. Eucera difficilis (*Duf.*) *Pér.* ♂, freq., skg. Verhoeff (Norderney).—**A. Diptera.** (*a*) *Bibionidae*: 1. Dilophus vulgaris *Mg.* one ♀ and one ♂. (*b*) *Empidae*: 2. Hilara quadrivittata *Mg.* one ♂. (*c*) *Muscidae*: 3. Calliphora erythrocephala *Mg.*, skg.; 4. Cynomyia mortuorum *L.* two ♂; 5. Cyrtoneura hortorum *Fall.* one ♂; 6. Hylemyia variata *Fall.* one ♂; 7. Lucilia caesar *L.* ♀ and ♂; 8. Limnophora protuberans *Zett.* ♀ and ♂; 9. Micropeza sp.; 10. Myospila meditabunda *F.* (*d*) *Syrphidae*: 11. Helophilus pendulus *L.*; 12. H. trivittatus *F.* one ♀; 13. Rhingia rostrata *L.* **B. Hymenoptera.** *Apidae*: 14. Bombus lapidarius *L.* ♀, skg.; 15. B. terrester *L.* ♀ and ☿, do.; 16. Colletes cunicularius *L.* ♀, skg. and po-cltg.; 17. Psithyrus vestalis *Fourcr.* ♀. **C. Lepidoptera.** *Pieridae*: 18. Pieris brassicae *L.*, skg.; 19. P. napi *L.*, do. Alfken (Juist), 2 humble-bees (Bombus hortorum *L.* ♂, and B. ruderatus *F.*). Wüstnei (Alsen), 5 bees—1. Cilissa tricincta *K.*; 2. Andrena tibialis *K.*; 3. A. chrysosceles *K.*; 4. Halictus cylindricus *F.* ♂; 5. Nomada fabriciana *L.*: (Flensburg), the bee Andrena labialis *K.* Krieger (Leipzig), 5 bees—1. Andrena albicans *Müll.*; 2. A. flavipes *Pz.*; 3. A. gwynana *K.*; 4. A. nigroaenea *K.*; 5. Halictus calceatus *Scop.* Schmiedeknecht (Thuringia), 8 bees—1. Andrena extricata *Sm.*; 2. A. flavipes *Pz.*; 3. A. humilis *Imh.*; 4. A. nitida *Fourcr.*; 5. A. parvula *K.*; 6. A. tibialis *K.*; 7. Bombus hypnorum *L.* ♀; 8. Psithyrus quadricolor *Lep.* ♀. Schletterer records 8 bees for the Tyrol (T.) and Pola (P.)—1. Andrena congruens *Schmiedekn.* (T.); 2. A. convexiuscula *K.* (P.); 3. Bombus hortorum *L.* (T.); 4. Dasypoda hirtipes *Pz.* (T.); 5. Halictus calceatus *Scop.*; 6. H. malachurus *K.* (P.); 7. H. morio *F.* (P.); 8. H. vulpinus *Nyl.* (T.). Herm. Müller (Alps), 9 beetles, 26 flies, 30 Hymenoptera, and 35 Lepidoptera. Redtenbacher (Austria), 2 beetles (Anthaxia nitidula *L.*, and Malachius gracilis *Mill.*). Schenck (Nassau), 13 bees—1. Andrena chrysosceles *K.*; 2. A. extricata *Sm.*; 3. A. flavipes *Pz.*; 4. A. fulvago *Chr.*; 5. A. nitida *Fourcr.*; 6. A. proxima *K.* ♂; 7. A. tibialis *K.*; 8. A. trimmerana *K.*; 9. Halictus flavipes *F.*; 10. H. levigatus *K.*;

11. H. rubicundus *Chr.* ♀; 12. H. rufocinctus (*Sich.*) *Nyl.*; 13. H. tetrazonius *Klg.* ♀. Schiner (Austria), the Muscid Tephritis conjuncta *Loew.* H. de Vries (Netherlands), 12 bees (Ned. Kruid. Arch., Nijmegen, 2. Ser., 2. Deel, 1875)—1. Andrena albicans *Müll.* ♀; 2. A. albicrus *K.* ♀; 3. A. fasciata *Wesm.* ♂; 4. A. nigroaenea *K.* ♀; 5. Apis mellifica *L.* ☿; 6. Chelostoma florisomne *L.* ♀; 7. Halictus cylindricus *F.* ♀; 8. H. leucozonius *Schr.* ♀; 9. H. rubicundus *Chr.* ♀; 10. H. seladonius *F.* ♀; 11. H. villosulus *K.* ♀; 12. Psithyrus vestalis *Fourcr.* ♀. MacLeod (Pyrenees), 9 Hymenoptera, 4 Lepidoptera, a beetle, and 10 flies (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 366–7): (Flanders), Apis, 4 humble-bees, 19 short-tongued bees, a Siricid, 3 hover-flies, 2 Empids, 8 Muscids, 2 Lepidoptera, and 2 beetles (op. cit., v, 1893, p. 432–3). Schneider (Arctic Norway) (Tromsø Mus. Aarsh., 1894), 8 bees—1. Bombus alpinus *L.* ☿; 2. B. hypnorum *L.* ☿; 3. B. lapponicus *L.* ☿ and ♂; 4. B. pratorum *L.* ☿ and ♂; 5. B. scrimshiranus *K.* ☿ and ♂; 6. B. terrester *L.* ☿ and ♂; 7. Psithyrus quadricolor *Lep.* ♂; 8. P. vestalis *Fourcr.* ♂. Warming (Greenland), the butterfly Colias boothi *H.-Sch.* (= C. hecla *Lef.*). Lindman (Dovrefjeld), numerous flies, several Lepidoptera, and a humble-bee. Scott-Elliot (Dumfriesshire), 4 short-tongued bees, an Empid, and 3 Muscids ('Flora of Dumfriesshire,' p. 104). Smith (England), 4 bees—1. Andrena albicans *Müll.*; 2. A. angustior *K.*; 3. A. nitida *Fourcr.*; 4. A. nigroaenea *K.* Saunders (England), 3 bees—1. Andrena extricata *Sm.*; 2. A. humilis *Imh.*; 3. A. labialis *K.*

1631. T. croceum Dahlstedt.—This is a sub-species of T. officinale defined by the author, and includes all the plants collected by Andersson and Hesselman in Spitzbergen ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora'). It also occurs in Iceland, and alpine Norway and Sweden. The heads attain a diameter of 26 mm. and close in bright sunshine between 5 and 6 p.m. The florets are orange-yellow in colour. With one exception the specimens collected in Spitzbergen were markedly female, so that the species is apparently apogamous.

1632. T. salinum Poll.—

Visitors.—Loew observed 2 hover-flies (Eristalis nemorum *L.*, and Syrphus ribesii *L.*) and a bee (Halictus zonulus *Sm.* ♂, skg.) in the Berlin Botanic Garden.

1633. T. phymatocarpum J. Vahl.—Ekstam states that in this species the diameter of the head is 35 mm. in Nova Zemlia. The florets are white and bright violet in colour, and faintly odorous. Autogamy or geitonogamy may be effected by spiral movements of the stylar branches. According to Ekstam ('Blütenbiol. Beob. a. Spitzbergen,' pp. 6–7), the capitula are white or bright violet in Spitzbergen, with a scarcely perceptible odour. At the beginning of July they are already partly over, and set fully mature fruits during the same month. Andersson and Hesselman ('Bidrag till Känned. om Spetsbergens o. Beeren Eil. Kärlväxtflora,' p. 15) found reduced anthers devoid of pollen in all the specimens they examined, so that the species is apparently apogamous. *Cf.* Raunkjaer's experiments, p. 683.

Visitors.—A small spider and a medium-sized fly were observed in Nova Zemlia.

498. Chondrilla L.

Florets yellow. The stylar branches roll back into a semicircle. Kerner says that geitonogamy is brought about in the same way as in Taraxacum.

1634. C. juncea L.—Kirchner says ('Beiträge,' p. 72) that each head in this species includes only 7–12 (usually 11) golden-yellow florets, and expands to

a diameter of 17 mm. All the florets of a head develop simultaneously. The anther-cylinder projects 3–4 mm. from the corolla-tube, and the style 3 mm. beyond this. The stylar branches only roll back far enough to form a semicircle, so that automatic self-pollination is excluded. On the other hand, according to Kerner, the stylar branches of the outer florets diverge far enough to touch the pollen of the inner ones, thus automatically effecting geitonogamy. Warnstorf states (Verh. bot. Ver., Berlin, xxxviii, 1896) that the florets open at Neu-Ruppin about 10 a.m., closing again between 2 and 3 p.m. The pollen-grains are golden-yellow in colour, spherical, densely covered with spinose tubercles, irregular in size, up to 50 μ in diameter.

VISITORS.—Schletterer records the bee Dasypoda plumipes *Pz.* for the Tyrol, and observed the fossorial wasp Notogonia pompiliformis *Kohl* at Pola.

499. Prenanthes Vaill.

Florets purple-red. Style entirely covered with pointed sweeping-hairs directed obliquely upwards, and extending considerably below the cleft: stylar branches beset internally with stigmatic papillae, and rolling far back. Kerner says that geitonogamy is brought about by the intertwining of the stylar branches of neighbouring florets when these begin to fade, so that the stigmas become dusted with any pollen that may remain.

1635. P. purpurea L.—In this species, according to Hermann Müller ('Weit. Beob.,' III, pp. 95–6), the heads consist of only 4–6 florets. The involucre is 12–14 mm. long, but only 2 mm. broad; the purple-red florets projecting from it possess ligules 10 mm. long and 3–4 mm. broad, so that the heads are moderately conspicuous. At a later stage the style projects 7 mm. beyond the anther-cylinder, which is 5–6 mm. long and scarcely $\frac{3}{4}$ mm. broad. Finally, the stylar branches (3 mm. in length) diverge and roll back into a spiral of $1\frac{1}{2}$ or 2 turns, so that in the absence of insect visitors automatic self-pollination is effected.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Bavarian Oberpfalz), a beetle (Agrilus coeruleus *Rossi*), a Muscid (Sarcophaga carnaria *L.*, po-dvg.), and 2 bees (Apis, freq., skg. and po-cltg.), and Andrena denticulata *K.* ♀). Hoffer (Steiermark), the humble-bee Bombus hypnorum *L.* ♂. Schletterer and von Dalla Torre (Tyrol), 2 humble-bees (Bombus confusus *Schenck*, and B. mastrucatus *Gerst.* ♀). MacLeod (Pyrenees), a Muscid (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 368). Loew (Berlin Botanic Garden), Apis, skg.

500. Lactuca L.

Florets yellow, rarely lilac in colour. Structure of the style as in Prenanthes. Kerner says that geitonogamy takes place when the florets begin to fade. He also states that the milky juice of many of the species is a protection against destructive animals.

1636. L. Scariola L. (Kirchner, 'Beiträge,' p. 72.)—Kirchner says that the diameter of the yellow heads, which consist of 20 florets, is about 20 mm. when fully open. Even before complete expansion, the pollen-covered style grows out

through the anther-cylinder, and soon afterwards the stylar branches diverge, lying about $1\frac{1}{2}$ mm. above the anther-cylinder and 5 mm. above the entrance to the corolla-tube. Towards the end of anthesis these branches roll back into a spiral of $1\frac{1}{2}$ turns, so that automatic self-pollination necessarily takes place if any pollen remains among the sweeping-hairs. Kerner says that the heads open about 8–9 a.m. at Innsbruck, closing again about 3–4 p.m.

VISITORS.—Kirchner observed a small bee.

1637. L. sativa L. (=L. Scariola *L.* according to the *Index Kewensis*). (Kirchner, 'Beiträge,' p. 73.)—Kirchner says that the flower mechanism is very similar to that of L. Scariola. Each head contains 10–16 yellow florets which develop simultaneously. The ligules are 11 mm. long, and are directed obliquely outwards, so that the diameter of the expanded head is about 15 mm. The anther-cylinder projects 4 mm. beyond the corolla-tube, which is $4\frac{1}{2}$ mm. in length. About 2 mm. above the anther-cylinder the stylar branches diverge: they ultimately roll back into a complete circle, so that automatic self-pollination necessarily results from contact of the stigmatic papillae with the pollen-grains clinging to the sweeping-hairs.

According to Linnaeus, the heads open about 7 a.m. at Upsala, closing again about 10 a.m. Kerner gives the corresponding times for Innsbruck as 8–9 a.m. and 1–2 p.m.

VISITORS.—Kirchner observed various flies.

1638. L. muralis Less. (=Prenanthes muralis *L.*). (Kirchner, 'Beiträge,' p. 73.)—Kirchner says that the heads of this species contain only 5, sometimes only 4, bright yellow florets, with ligules that spread out horizontally, or sometimes bend a little downwards, so that the inflorescence attains a diameter of 13–14 mm. The florets of each head develop simultaneously. Even before complete expansion the styles project from the anther-cylinders. They grow so far in an oblique direction that their tips stand about 5 mm. above the level of the head. The stylar branches at first curve outwards from each other, and subsequently roll downwards, though not far enough to touch the pollen remaining among the sweeping-hairs.

Warnstorf (Verh. bot. Ver., Berlin, xxxviii, 1896), however, observed the stylar branches rolling back till they came into contact with the pollen, so that autogamy necessarily took place. Geitonogamy, on the other hand, is only possible when the head is closed. The pollen-grains are yellow in colour, polyhedral, with spinose tubercles on their edges, from 40 μ to 43 μ in diameter.

At Neu-Ruppin the heads open between 6 and 7 a.m., closing again between 4 and 5 p.m. Kerner says that they open at Innsbruck between 7 and 8 a.m., and close again about 2 or 3 p.m.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Kirchner (Stuttgart), 2 flies, a small bee, and the beetle Meligethes. Herm. Müller (Fichtelgebirge), a Muscid (Echinomyia grossa *L.*, po-dvg.), and a bee (Halictus albipes *F.*, skg.) ('Weit. Beob.,' III, p. 96). MacLeod (Pyrenees), a bee of the genus Panurgus (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 367).

1639. L. perennis L. (Herm. Müller, 'Alpenblumen,' pp. 463–4.)—In this species each head contains about 16 florets, which spread out their ligules (16–18 mm.

long) in the midday sun, to give a violet star about 40 mm. in diameter. The stylar branches ultimately roll back, often so far that their stigmatic inner surfaces touch their outer surfaces, to which some pollen often remains clinging. As in the case of the last species, the florets of each head develop simultaneously, being first male and then female, so that insect visitors necessarily effect cross-pollination. Kerner says that at Innsbruck the heads open between 6 and 7 a.m., closing again about 5 or 6 p.m.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), a fly and a beetle. Loew (Berlin Botanic Garden).—**A. Coleoptera.** *Telephoridae*: 1. Dasytes flavipes *F.* **B. Diptera.** *Syrphidae*: 2. Syrphus luniger *Mg.* **C. Hymenoptera.** *Apidae*: 3. Chelostoma nigricorne *Nyl.* ♂, skg.

1640. L. viminea J. et C. Presl.—

VISITORS.—Loew (Berlin Botanic Garden) observed a beetle (Anthaxia quadripunctata *L.*) and 3 bees (1. Megachile centuncularis *L.* ♂, skg.; 2. Prosopis armillata *Nyl.* ♀, do.; 3. Stelis aterrima *Pz.* ♀, do.).

501. Mulgedium Cass.

Florets blue. Style covered externally with very sharp thorn-like sweeping-hairs, extending far down its undivided part, but denser on its branches. The inner surfaces of the latter beset with stigmatic papillae. Kerner states that the stylar branches diverge so far when the florets fade as to touch the outer surfaces of adjacent branches, and as they are still covered with pollen geitonogamy is effected.

1641. M. alpinum Less. (=Sonchus alpinus *L.*, and Lactuca alpina *Benth. et Hook. f.*). (Herm. Müller, 'Alpenblumen,' pp. 459–60.)—In this species about 20 florets are aggregated into a head which in the closed condition is only 4 mm. in diameter, but 20–30 mm. when expanded in the sunshine. The stylar branches are 2 mm. long; they diverge in the second stage of anthesis, but never roll back far enough to effect automatic self-pollination.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Vosges), Apis, a humble-bee, a Lepidopterid, and a beetle. Lindman (Dovrefjeld), a humble-bee. Loew (Berlin Botanic Garden), 6 bees—1. Bombus lapidarius *L.* ♀ and ☿, skg.; 2. Chelostoma nigricorne *Nyl.* ♂, do.; 3. Halictus sexcinctus *F.* ♀, do.; 4. Osmia fulviventris *Pz.* ♂ and ♀, do.; 5. Osmia rufa *L.* ♀, po-cltg.; 6. Stelis phaeoptera *K.* ♂, skg.

1642. M. macrophyllum DC. (=Lactuca macrophylla *A. Gray*).—

VISITORS.—Loew (Berlin Botanic Garden) observed a hover-fly (Melanostoma mellina *L.*) and a bee (Chelostoma nigricorne *Nyl.* ♂, skg.).

1643. M. prenanthoides DC.—

VISITORS.—Loew (Berlin Botanic Garden) observed 2 hover-flies (Didea intermedia *Loew*, skg., and Syrphus balteatus *Deg.*, licking the style).

1644. M. Plumieri DC. (=Sonchus Plumieri *L.*, and Lactuca Plumieri *Gren. et Godr.*).—Kerner says that the heads of this species open at Innsbruck about 6–7 a.m., closing again about 8–9 p.m.

502. Sonchus Tourn.

Florets yellow. Style covered externally with sweeping-hairs directed obliquely upwards: stylar branches beset with stigmatic papillae internally.

1645. S. oleraceus L. (Kirchner, 'Flora v. Stuttgart,' p. 745; Herm. Müller, 'Fertilisation,' p. *361*; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. *98*, *162*.)—In this species the expanded heads are about 20 mm. in diameter, and Kirchner says they contain about 120 bright-yellow florets, the marginal ones being tinged with reddish-grey on the outside. The corolla-tube is 10 mm. and the ligule 6 mm. long; the anther-cylinder is orange-yellow, while the style and its branches (scarcely 1 mm. long) are covered with blackish sweeping-hairs. The branches ultimately diverge and bend round into a semicircle. Linnaeus says that the heads open at Upsala at 5 a.m., closing again between 11 a.m. and 12 noon. Kerner gives the corresponding times for Innsbruck as 6–7 a.m. and 1–2 p.m.

Visitors.—*The following were recorded by the observers, and for the localities* stated.—

Knuth (Schleswig-Holstein), a humble-bee, 2 hover-flies, and a Lepidopterid. Herm. Müller (Westphalia), 3 hover-flies (1. Eristalis arbustorum *L.*; 2. Syrphus arcuatus *Fall.*; 3. S. balteatus *Deg.*: all skg. and po.-dvg.) and a butterfly (Pieris brassicae *L.*, skg.). Schletterer (Pola), the small bee Halictus villosulus *K.* Scott-Elliot (Dumfriesshire), 2 hover-flies and 3 Muscids ('Flora of Dumfriesshire,' p. 103).

1646. S. arvensis L. (Kirchner, 'Flora v. Stuttgart,' p. 745.)—Kirchner says that in this species the heads contain over 200 golden-yellow florets, and spread out to a diameter of 40–50 mm. The corolla-tube is 8–12 mm. and the ligule 8–14 mm. in length. The stylar branches ultimately roll back so far as to make a spiral of *three turns, and of course automatic self-pollination is thereby effected.*

The marginal florets close in dull weather. Linnaeus says that the heads open at Upsala in clear weather about 6–7 a.m., closing again at 10 a.m. The times given by Kerner are about 7–8 a.m. and 12–1 p.m.

Visitors.—Knuth observed the following.—

In Schleswig-Holstein ('Bl. u. Insekt. a. d. nordfr. Ins.,' p. 162; Weit. Beob. ü. Bl. u. Insekt. a. d. nordfr. Ins., p. 237).—**A. Diptera.** *Syrphidae*: all skg.: 1. Eristalis arbustorum *L.*; 2. E. tenax *L.*; 3. Syrphus balteatus *Deg.*; 4. S. pyrastri *L.*; 5. S. ribesii *L.* **B. Hymenoptera.** *Apidae*: 6. Apis mellifica *L.*, skg. and po-cltg.; 7. Dasypoda plumipes *Pz.*, po-cltg. **C. Lepidoptera.** *Rhopalocera*: 8. Pieris napi *L.*, skg.; 9. P. rapae *L.*, do. In Helgoland ('Bl. u. Insekt. a. Helgoland'), the Muscid Lucilia caesar *L.*, common, and small Muscids.

Alfken gives the following.—

In Juist.—**A. Diptera.** (*a*) *Muscidae*: 1. Cynomyia mortuorum *L.* (*b*) *Syrphidae*: 2. Eristalis arbustorum *L.* **B. Hymenoptera.** (*a*) *Apidae*: 3. Bombus lapidarius *L.* ☿; 4. B. muscorum *F.* ♂; 5. B. terrester *L.*; 6. Dasypoda plumipes *Pz.* ♀, freq., po-cltg. (*b*) *Sphegidae*: 7. Oxybelus mucronatus *F.*, very common; 8. O. uniglumis *L.*, rare. **C. Lepidoptera.** *Pieridae*: 9. Pieris brassicae *L.* At Bremen, 4 bees—1. Bombus lapidarius *L.* ☿; 2. B. muscorum *F.* ♂; 3. B. terrester *L.* ☿; 4. Dasypoda plumipes *Pz.* ♀ and ♂.

Herm. Müller gives the following list for Westphalia ('Fertilisation,' p. 361).—

A. Coleoptera. (*a*) *Curculionidae*: 1. Spermophagus cardui *Stev.*, in large numbers. (*b*) *Telephoridae*: 2. Malachius sp., po-dvg. **B. Diptera.** (*a*) *Conopidae*: 3. Sicus ferrugineus *L.*, skg. (*b*) *Syrphidae*: 4. Cheilosia sp., po-dvg.; 5. Eristalis arbustorum *L.*, skg. and po-dvg., freq.; 6. E. tenax *L.*, do. **C. Hymenoptera.** *Apidae*: 7. Apis mellifica *L.* ☿, very common, skg. and po-cltg.; 8. Bombus sp., skg.; 9. Halictus flavipes *F.* ♀, po-cltg.; 10. H. lugubris *K.* ♂, skg.; 11. H. quadricinctus *F.* ♀, po-cltg.; 12. H. rubicundus *Chr.* ♀, po-cltg. and skg.; 13. Megachile centuncularis *L.* ♀, do.; 14. Nomada varia *Pz.* ♀, skg.; 15. Osmia spinulosa *K.* ♀, po-cltg. and skg. (Thuringia); 16. Panurgus banksianus *K.* ♀ and ♂, not very freq.; 17. P. calcaratus *Scop.* ♀ and ♂, very common, skg. and po-cltg. **D. Lepidoptera.** *Rhopalocera*: 18. Hesperia sp., skg.

The following were recorded by the observers, and for the localities stated.—

H. de Vries (Netherlands), a humble-bee (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). MacLeod (Flanders), 2 hover-flies (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 434). Scott-Elliot (Dumfriesshire), several flies (Scott-Elliot, 'Flora of Dumfriesshire,' p. 103).

1647. S. asper Hill.—The florets of this species are yellow in colour.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller ('Weit. Beob.,' III, p. 96).—**A. Diptera.** *Muscidae*: 1. Anthomyia sp., po-dvg. **B. Hymenoptera.** *Apidae*: 2. Chelostoma campanularum *L.* ♂, skg.; 3. Coelioxys rufescens *Lep.* ♂, do.; 4. Halictus morio *F.* ♂, do.; 5. H. smeathmanellus *K.* ♀, do.; 6. Prosopis armillata *Nyl.* ♂, do.; 7. Stelis aterrima *Pz.* ♀, do. Schletterer (Pola), the bee Osmia rufohirta *Ltr.* MacLeod (Flanders), 2 short-tongued bees, 3 hover-flies, 2 Muscids and a Lepidopterid (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 433). Alfken (Juist), the bee Dasypoda plumipes *Pz.* ♂. Verhoeff (Norderney), the humble-bee Bombus lapidarius *L.* ♂.

503. Crepis L.

Florets yellow. The whole outer surface of the stylar branches covered with spinose sweeping-hairs, which extend down the margins of the style below the cleft, as far as the anther-cylinder. The inner surfaces of the branches are beset with stigmatic papillae up to their edges. Kerner says that the stylar branches of the outer florets diverge and roll back so as to touch the pollen of the inner ones. In addition to this geitonogamy, automatic self-pollination also takes place by elongation of the ligules and the consequent raising of the pollen adhering to them, until it is brought into contact with the stigmatic papillae.

1648. C. biennis L. (Kirchner, 'Flora v. Stuttgart,' p. 747.)—Kirchner says that the golden-yellow florets of this species are aggregated into heads of which the upper surface is 35–40 mm. broad when expanded. The corolla-tube is 5 mm. and the ligule 12–16 mm. long. The stylar branches ultimately roll back into a spiral of two turns, so that in the absence of insect visitors automatic self-pollination necessarily takes places.

Visitors.—Herm. Müller observed the following ('Fertilisation,' p. 353, 'Weit. Beob.,' III, pp. 93–4).—

A. Coleoptera. (*a*) *Chrysomelidae*: 1. Cryptocephalus sericeus *L.*, dvg. the anthers (Thuringia). (*b*) *Nitidulidae*: 2. Meligethes, in large numbers. **B. Diptera.**

(*a*) *Muscidae*: 3. Gonia capitata *Fall.*, skg. (Thuringia). (*b*) *Syrphidae*: 4. Cheilosia chrysocoma *Mg.*, po-dvg.; 5. Eristalis arbustorum *L.*, very common, skg. and po-dvg.; 6. E. nemorum *L.*, do.; 7. E. sepulcralis *L.*, do.; 8. E. tenax *L.*, do.; 9. Syritta pipiens *L.*, do.; 10. Syrphus sp., po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 11. Andrena denticulata *K.* ♀ and ♂, po-cltg. and skg.; 12. A. dorsata *K.* ♀, po-cltg.; 13. A. fulvago *Chr.* ♀, do. (Thuringia); 14. A. fulvescens *Sm.* ♀, do. (Thuringia); 15. A. parvula *K.* ♂, skg.; 16. A. zonalis *K.* ♂, do. (Thuringia); 17. Apis mellifica *L.* ☿, do.; 18. Chelostoma campanularum *K.* ♀ and ♂, very numerous, po-cltg. and skg.; 19. Dasypoda hirtipes *F.* ♂, freq., still resting on the florets in the evening; 20. Halictus albipes *F.* ♀, skg. and po-cltg.; 21. H. cylindricus *F.* ♀ do., ♂ skg., freq.; 22. H. flavipes *F.* ♂, skg.; 23. H. leucopus *K.* ♀, po-cltg. (Buddeburg, Nassau); 24. H. leucozonius *Schr.* ♀ skg. and po-cltg., ♂ freq. skg.; 25. H. longulus *Sm.* ♀, do.; 26. H. lugubris *K.* ♂, skg.; 27. H. maculatus *Sm.* ♀, skg. and po-cltg.; 28. H. nitidus *Schenck* ♀, do.; 29. H. quadricinctus *F.* ♂, freq., skg.; 30. H. rubicundus *Chr.*, ♂, skg.; 31. H. sexcinctus *F.* ♀, do. (Thuringia); 32. H. villosulus *K.* ♀, very numerous, skg. and po-cltg. (Thuringia); 33. H. zonulus *Sm.*, ♀, po-cltg. (Thuringia); 34. Heriades truncorum *L.* ♀ and ♂, very numerous, skg. and po-cltg.; 35. Osmia spinulosa *K.* ♀ and ♂, do. (Thuringia); 36. Panurgus banksianus *K.* ♀ and ♂, freq., po-cltg. and skg., rolling about among the florets; 37. P. calcaratus *Scop.* ♀ and ♂, do.; 38. Dufourea vulgaris *Schenck* ♀ and ♂, very numerous (Thuringia); 39. Stelis breviuscula *Nyl.* ♂, skg. (Thuringia); 40. S. phaeoptera *K.*, do. (Thuringia). (*b*) *Tenthredinidae*: 41. Tarpa cephalotes *F.*, freq., skg. (Thuringia). **D. Lepidoptera.** (*a*) *Rhopalocera*: all skg.: 42. Argynnis latonia *L.* (Bavarian Oberpfalz); 43. Epinephele janira *L.* (Thuringia); 44. Lycaena sp. (Thuringia); 45. Melitaea athalia *Esp.* (Thuringia); 46. Thecla sp. (Thuringia). (*b*) *Sphingidae*: 47. Zygaena lonicerae *Esp.*, skg. (Thuringia).

The following were recorded by the observers, and for the localities stated.—

Loew (Berlin Botanic Garden), 2 bees (Dasypoda hirtipes *F.* ♂, several, skg., and Osmia fulviventris *Pz.* ♀, po-cltg.). Alfken (Bremen).—**A. Diptera.** *Syrphidae*: all freq.: 1. Eristalis arbustorum *L.*; 2. E. nemorum *L.*; 3. E. pertinax *Scop.*; 4. E. sepulcralis *L.*; 5. Syrphus pyrastri *L.*; 6. Volucella bombylans *L.*, var. bombylans *Mg.* **B. Hymenoptera.** *Apidae*: 7. Andrena albicans *Müll.* ♀; 8. A. flavipes *Pz.* ♀; 9. A. parvula *K.* ♀; 10. Bombus hortorum *L.* ☿; 11. B. lapidarius *L.* ☿; 12. Eriades truncorum *L.* ♀; 13. Eucera difficilis (*Duf.*), *Pér.* ♂; 14. Halictus leucozonius *Schr.* ♀, freq., po-cltg.; 15. Osmia solskyi *Mor.* ♀, one, po-cltg.; 16. Panurgus banksianus *K.* ♀ and ♂; 17. Psithyrus rupestris *F.* ♀, skg. Schmiedeknecht (Thuringia), 2 bees (Andrena flessae *Pz.*, and A. humilis *Imh.*). Schenck (Nassau), 2 bees (Andrena fulvago *Chr.*, and Osmia caerulescens *L.* ♂).

1649. C. virens L.—

VISITORS.—Herm. Müller (H. M.) ('Fertilisation,' p. 353, 'Weit. Beob.,' III, p. 94) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Coleoptera. *Mordellidae*: 1. Mordella fasciata *F.* (H. M.). **B. Diptera.** (*a*) *Conopidae*: 2. Occemyia atra *F.*, skg. (H. M.); 3. Sicus ferrugineus *L.*, do. (H. M.). (*b*) *Syrphidae*: 4. Cheilosia chrysocoma *Mg.*, po-dvg. (Borgstette); 5. Eristalis tenax *L.*, do. (H. M.); 6. Melithreptus scriptus *L.*, do. (H. M.); 7. M. taeniatus *Mg.*, do. (H. M.); 8. Syrphus arcuatus *Fall.*, do. (H. M); 9. S. balteatus *Deg.*, do. (H. M.); 10. S. ribesii *L.*, do. (H. M.). **C. Hymenoptera.** *Apidae*: 11. Andrena denticulata *K.*, ♀, po-cltg. (H. M., Borgstette); 12. A. dorsata *K.* ♂, skg. (H. M.); 13. A. fulvago *Chr.* ♀, skg. and po-cltg. (Budd.); 14. A. xanthura *K.* ♀, po-cltg. (Budd.); 15. Chelostoma campanularum *L.* ♀, skg. (Budd.); 16. Dasypoda hirtipes *F.* ♂, not infrequent, skg. (H. M., Budd.); 17. Dufourea vulgaris *Schenck* ♀ and ♂, po-cltg. and skg. (H. M., Bavarian Oberpfalz); 18. Halictus cylindricus *F.* ♀, po-cltg. (H. M.); 19. H. lucidus *Schenck* ♀, skg. (Budd.); 20. H. minutus *K.* ♀,

po-cltg. (H. M.); 21. H. morio *F.* ♂ (Budd.); 22. H. smeathmanellus *K.* ♀, skg. and po-cltg (Budd.); 23. H. villosulus *K.* ♀, po-cltg. (H. M.); 24. H. zonulus *Sm.* ♀, do. (Budd.); 25. Panurgus banksianus *K.* ♀ and ♂, rare (H. M.); 26. P. calcaratus *Scop.* ♀ and ♂, freq., skg. and po-cltg., rolling about among the florets (H. M., Budd.); 27. Prosopis propinqua *Nyl.* ♀, skg. (Budd.); 28. Stelis aterrima *Pz.* ♀, do. (Budd.). **D. Lepidoptera.** *Rhopalocera*: 29. Pieris rapae *L.*, skg. (H. M., Bavarian Oberpfalz.)

The following were recorded by the observers, and for the localities stated.—

H. de Vries (Netherlands), 2 humble-bees (Bombus subterraneus *L.* ☿, and B. terrester *L.* ☿) (Ned. Kruidk. Arch. Nijmegen, 2. Ser., 2. Deel, 1875). MacLeod (Flanders), a humble-bee, 6 short-tongued bees (among them 2 species of Panurgus), 8 hover-flies, 4 Muscids, and 6 Lepidoptera (Bot. Jaarb. Dodonaea, Ghent, v, 1893, p. 434): (Pyrenees), 4 Hymenoptera (among them a species of Panurgus), a beetle, and 6 flies (op. cit., iii, 1891, p. 368). Scott-Elliot (Dumfriesshire), 3 short-tongued bees, a saw-fly, several flies, and a beetle ('Flora of Dumfriesshire,' p. 104). Alfken (Bremen), 12 bees—1. Andrena denticulata *K.* ♀; 2. A. fucata *Sm.* ♀; 3. Dasypoda plumipes *Pz.* ♀; 4. Eriades truncorum *L.* ♀; 5. Halictus leucozonius *Schr.* ♀; 6. H. punctatissimus *Schenck* ♀; 7. H. punctulatus *K.* ♀; 8. Nomada flavoguttata *K.* ♀ and ♂; 9. N. fuscicornis *Nyl.* ♀; 10. Osmia solskyi *Mor.* ♀; 11. Panurgus banksianus *K.* ♀ and ♂; 12. P. calcaratus *Scop.* ♀ and ♂.

1650. C. tectorum L.—Warnstorf describes the flower mechanism of this species as follows (Verh. bot. Ver., Berlin, xxxvii, 1896).—

The long stylar branches are covered with spinose sweeping-hairs, all of which project at right angles, and not only push out from the anther-cylinder, but also hold fast the polyhedral pollen-grains. These are covered with minute drops of oil, and beset with spinose warts on their edges. In the second stage of anthesis the stylar branches roll spirally downwards, and thus come into contact with the pollen-grains that still remain among the sweeping-hairs, so that if crossing has not been effected by insects, autogamy is rendered possible.

Visitors.—Herm. Müller (H. M.) ('Fertilisation,' p. 353, 'Weit. Beob.,' III, p. 94) in Westphalia, Buddeberg (Budd.) in Nassau, and Borgstette (Borg.) in Tecklenburg observed the following.—

A. Diptera. *Syrphidae*: 1. Cheilosia chrysocoma *Mg.*, po-dvg. (Borg.); 2. Eristalis sepulcralis *L.*, do. (Budd.). **B. Hymenoptera.** (*a*) *Apidae*: 3. Andrena chrysopyga *Schenck*, po-dvg. (H. M., Thuringia); 4. A. denticulata *F.* ♀ and ♂ (Borg.); 5. A. fulvicrus *K.* ♀, po-cltg. (H. M.); 6. Halictus malachurus *K.* ♀, skg. and po-cltg. (Budd.); 7. H. quadricinctus *F.* ♂, freq. (H. M.); 8. H. rubicundus *Chr.* ♂, skg. (H. M.); 9. H. villosulus *K.* ♀, po-cltg. (H. M.); 10. Heriades truncorum *L.* ♂, skg. (H. M.); 11. Osmia spinulosa *K.* ♀, freq., po-cltg. (H. M.); 12. Dufourea vulgaris *Schenck* ♀ and ♂ (H. M.). (*b*) *Sphegidae*: 13. Pompilus viaticus *L.* ♀, skg. (H. M.).

Loew records a bee (Halictus punctulatus *K.* ♂, skg.) and a butterfly (Polyommatus virgaureae *L.*, skg.) for Silesia ('Beiträge,' p. 31); and a bee (Halictus vulpinus *Nyl.* ♀, po-cltg.) for Switzerland (op. cit., p. 58).

1651. C. pulchra L.—Kerner states that the heads of this species open at Innsbruck about 6–7 a.m., closing again about 9–10 a.m.

1652. C. Jacquini Tausch (=Hieracium chondrilloides *L.*).—Linnaeus says that the heads of this species open at Upsala about 9 a.m., and close again about 1 p.m.

1653. **C. rubra** L.—This South European species opens its heads at Innsbruck, according to Kerner, about 7–8 a.m., closing them again about 6–7 p.m.

VISITORS.—Schletterer and von Dalla Torre (Tyrol) observed 3 bees—1. Andrena albicrus *K.* ♀ and ♂; 2. Halictus sexnotatus *K.* ♀; 3. Prosopis annulata *L.* ♀ and ♂.

1654. **C. aurea** Reichb. (=Hieracium aureum *Scop.*, Leontodon aurea *L.*). (Herm. Müller, 'Alpenblumen,' pp. 462–3.)—In this species there are usually over 100 florets in the head, which expands in the sunshine to a diameter of 35–60 mm. The anther-cylinder projects as much as 6–7 mm. from the corolla-tube, and in the second stage of anthesis the style extends 5½ mm. further. The stylar branches are 3 mm. long, and curve away from each other, though only in individual cases to such an extent as to render automatic self-pollination possible.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 2 beetles, 4 flies, 3 Hymenoptera, and 19 Lepidoptera. Loew (Switzerland) ('Beiträge,' p. 58), a Bombyliid (Nemeophila plantaginis *L.*), a Noctuid moth (Agrotis ocellina *S.-V.*), and a butterfly (Argynnis selene *S.-V.*). von Dalla Torre (Tyrol), the humble-bee Bombus mastrucatus *Gerst.* Schletterer (Tyrol), 3 bees—1. Bombus mastrucatus *Gerst.*; 2. Halictus levis *K.* (=H. fulvicornis *K.*); 3. H. smeathmanellus *K.*

It is noteworthy that the orange-red florets are chiefly visited by red butterflies (Argynnis, Melitaea, species of Polyommatus). (*Cf.* Senecio abrotanifolius and Hieracium aurantiacum, and the note in Vol. I, p. 144.)

1655. **C. paludosa** Moench (=Hieracium paludosum *L.*).—

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), a Lepidopterid. Buddeberg (Nassau) (Herm. Müller, 'Weit. Beob.,' III, p. 94), 6 bees—1. Andrena fulvago *Chr.* ♀, skg.; 2. Halictus leucozonius *Schr.* ♀; 3. H. quadricinctus *F.* ♀, skg. and po-cltg.; 4. H. tetrazonius *Klg.*, do.; 5. Osmia aenea *L.* ♂, skg.; 6. O. rufa *F.* ♀, do. MacLeod (Pyrenees), a Muscid (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, p. 369). Scott-Elliott (Dumfriesshire), a saw-fly, 4 hover-flies, and a Muscid ('Flora of Dumfriesshire,' p. 105).

1656. **C. montana** Tausch.—

VISITORS.—Loew observed 2 bees (Chelostoma nigricorne *Nyl.* ♂, skg., and Osmia fulviventris *Pz.* ♀, po-cltg.) in the Berlin Botanic Garden.

1657. **C. rigida** Waldst. et Kit.—

VISITORS.—Loew observed 2 hover-flies (Eristalis nemorum *L.*, and E. tenax *L.*) and a bee (Megachile centuncularis *L.* ♀, po-cltg.) in the Berlin Botanic Garden.

1658. **C. sibirica** L.—

VISITORS.—Loew observed the bee Stelis phaeoptera *K.* ♀, skg., in the Berlin Botanic Garden.

1659. **C. succisaefolia** Tausch.—

VISITORS.—Loew observed the bee Osmia fulviventris *Pz.* ♀, po-cltg., in the Berlin Botanic Garden.

1660. C. albida Vill.—The florets of this species are of a yellowish colour.

Visitors.—MacLeod (Pyrenees) observed 4 bees, a Lepidopterid, 4 beetles, a Syrphid, and 2 Muscids.

1661. C. grandiflora Tausch. (Kerner, 'Nat. Hist. Pl.,' Eng. Ed. 1, II.)—Kerner has observed that when the heads of this species close in the evening they are used as quarters for the night by some of the smaller beetles (Cryptocephalus, Meligethes) and bees (Panurgus ursinus *Ltr.*), for at that time their interior is warmer than the surrounding air. These insects leave their refuge at sunrise, and being dusted with pollen transfer this to other flowers which they visit.

Kerner has also noticed that autogamy is effected by the shrivelling and spiral twisting of the stylar branches, which are thus brought into contact with the pollen of their own florets.

504. Hieracium L.

Florets usually bright-yellow to golden-yellow in colour, rarely orange. The part of the style which projects from the anther-cylinder is completely covered with pointed spinose sweeping-hairs, while the inner surfaces of the stylar branches are beset with stigmatic papillae. Kerner states that geitonogamy takes place as in Crepis, and that as in that genus automatic self-pollination is rendered possible by subsequent elongation of the corolla.

Ostenfeld and Raunkjær (Bot. Tids., Kjöbenhavn, xxv, 1902, pp. 409–13) castrated the flowers of a number of species by the method used in the case of Taraxacum (*cf.* 683), and obtained parthenogenetically formed fruits, though no germinating pollen-grains were observed on the stigmas. In the case of one species (H. hyparcticum *Almq.*) plants were raised from such fruits.

1662. H. Pilosella L. (Herm. Müller, 'Fertilisation,' pp. 355–6, 'Weit. Beob.,' p. 93, 'Alpenblumen,' p. 460; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 98, 162, 'Bloemenbiol. Bijdragen'; de Vries, Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875; MacLeod, Bot. Jaarb. Dodonaea, Ghent, iii, 1891, v, 1893; Loew, 'Blütenbiol. Floristik,' pp. 390–8.)—*Cf.* Fig. 210. Hermann Müller states that the heads of this species contain 42–64 florets of a bright sulphur-yellow colour, the marginal ones being usually streaked with red. During sunny weather the heads expand (according to Linnaeus from 7 a.m. to 3 p.m.) to a diameter of 20 mm. They are closed in the evening and at night, also during dull weather. The florets increase in size from the centre to the periphery; their corolla-tube is 3–6 mm. and their ligule from 4–8 mm. long. In the first stage of anthesis the sweeping-hairs of the style brush the accumulated pollen out of the anther-cylinder, after which the stylar branches curve back to such an extent that automatic self-pollination becomes possible.

Visitors.—Alfken and Höppner (H.) observed the following at Bremen.—

A. Coleoptera. *Buprestidae*: 1. Anthaxia quadripunctata *L.*, freq. **B. Diptera.** *Syrphidae*: 2. Cheilosia soror *Zett.*, skg.; 3. Eristalis tenax *L.*, freq., skg.; 4. Helophilus trivittatus *F.*, very common, skg. **C. Hymenoptera.** (*a*) *Apidae*: 5. Andrena albicans *Müll.* ♀ and ♂, rare; 6. A. albicrus *K.* ♂, freq., skg.; 7. A. argentata *Sm.* ♀, rare, po-cltg.; 8. A. chrysopyga *Schenck* ♂, rare; 9. A. convexiuscula *K.* ♀ and ♂, do.; 10. A. fulvago *Chr.*, very rare, ♀ skg., po-cltg., ♂ skg.; 11. A.

fulvida *Schenck* ♀, very rare; 12. A. humilis *Imh.*, the commonest visitor, exceedingly numerous, ♀ po-cltg. and skg., ♂ skg.: they roll about among the florets as bees of their kind usually do; 13. A. labialis *K.* ♂, rare; 14. A. parvula *K.* ♀, rare, skg. and po-cltg.; 15. A. praecox *Scop.* ♀, rare; 16. A. proxima *K.* ♀ and ♂, rare, skg.; 17. A. xanthura *K.* ♀ and ♂, rare; 18. Bombus variabilis *Schmiedekn.* ♀ (H.); 19. Eriades florisomnis *L.* ♀ and ♂; 20. Halictus calceatus *Scop.* ♀, very common, skg. and po-cltg.; 21. H. flavipes *F.* ♀, do.; 22. H. leucozonius *Schr.* ♀, an extremely common visitor, skg. and po-cltg.; 23. H. minutus *K.* ♀, rare; 24. H. nitidiusculus *K.* ♀, freq., po-cltg. and skg.; 25. H. punctatissimus *Schenck* ♀, not infrequent; 26. H. punctulatus *K.* ♀; if one of the small black bees belonging to the genus Halictus is taken on Hieracium Pilosella it is usually one of this species; extremely numerous (often 4 or 5 on one head), skg.; 27. H. rubicundus *Chr.*, freq., skg. and po-cltg.; 28. H. zonulus *Sm.*, rare, po-cltg. and skg.; 29. Megachile circumcincta *K.* ♂; 30. Nomada bifida *Ths.*, rare; 31. N. ferruginata *K.* ♂, very rare; 32. N. flavoguttata *K.* ♂, freq., skg.; 33. N. ochrostoma *K.* ♀ and ♂, rare, skg.; 34. Osmia claviventris *Ths.* ♀, once; 35. O. solskyi *Mor.* ♀ and ♂, rare; 36. Panurgus banksianus *K.* ♀, skg. and po-cltg., ♂ skg. (*b*) *Tenthredinidae*: 37. Cephus nigrinus *Ths.* ♀ and ♂, skg.

Herm. Müller (H. M.) and Buddeberg (Budd.) give the following list for Westphalia and Nassau.—

A. Coleoptera. (*a*) *Buprestidae*: 1. Anthaxia nitidula *L.* (Budd.). (*b*) *Cerambycidae*: 2. Leptura livida *L.* (H. M.). (*c*) *Chrysomelidae*: 3. Cryptocephalus moraei *L.*, freq. (H. M., Bavarian Oberpfalz); 4. C. sericeus *L.*, do. (H. M.). (*d*) *Oedemeridae*: 5. Oedemera livida *Marsh.*, po-dvg. (Budd.). **B. Diptera.** (*a*) *Bombyliidae*: 6. Bombylius canescens *Mik.* (Sauerland), skg. (H. M.). (*b*) *Conopidae*: 7. Sicus ferrugineus *L.*, skg. (H. M., Bavarian Oberpfalz). (*c*) *Syrphidae*: 8. Helophilus floreus *L.*, po-dvg. (H. M.). **C. Hymenoptera.** (*a*) *Apidae*: 9. Andrena cyanescens *Nyl.* ♀, skg. and po-cltg. (H. M.); 10. A. fulvago *Chr.* ♀, in large numbers, skg. and po-cltg. (H. M., Budd.); 11. A. fulvescens *Sm.* ♀, po-cltg. and skg. (H. M.); 12. Ceratina callosa *F.* ♀, skg. (Budd.); 13. C. cyanea *K.* ♂, occasional, do., skg. (H. M., Budd.); 14. Diphysis serratulae *Pz.* ♂, do. (H. M.); 15. Halictus cylindricus *F.* ♀, skg. (H. M., Bavarian Oberpfalz); 16. H. leucopus *K.* ♀, skg. and po-cltg. (Budd.); 17. H. leucozonius *Schr.* ♀, po-cltg. (H. M., Bavarian Oberpfalz); 18. H. maculatus *Sm.* ♀, skg. and po-cltg. (H. M., Bavarian Oberpfalz); 19. H. nitidus *Schenck* ♀, do. (H. M., Bavarian Oberpfalz); 20. H. tetrazonius *Klg.* ♀, skg. (Budd.); 21. H. villosulus *K.*, skg. and po-cltg. (H. M., Budd.); 22. Nomada fabriciana *L.*, ♀, skg. (H. M.); 23. Osmia aenea *L.* ♂, do. (Budd.); 24. Panurgus banksianus *K.* ♂ and ♀, skg. and po-cltg. (H. M., Bavarian Oberpfalz and Thuringia); 25. P. calcaratus *Scop.* ♀ and ♂, freq., po-cltg. and skg. (H. M.); 26. Prosopis armillata *Nyl.* ♀, skg. and po-cltg. (H. M.); 27. Sphecodes gibbus *L.* ♀, skg. (H. M., Bavarian Oberpfalz). (*b*) *Tenthredinidae*: 28. Cephus, small species, innumerable (H. M.). **D. Lepidoptera.** (*a*) *Noctuidae*: 29. Euclidia mi *L.*, skg. (H. M.). (*b*) *Rhopalocera*: 30. Lycaena argiolus *L.*, skg. (H. M.); 31. Pieris brassicae *L.*, do. (H. M.); 32. Polyommatus dorilis *Hfn.*, do. (Budd.).

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands and at Kiel), a bee (Panurgus sp.), a butterfly (Pieris sp.), 5 hover-flies, and small Muscids: (Helgoland), small Muscids: (Thuringia) ('Blütenbiol. Beob. in Thüringen,' p. 38).—**A. Coleoptera.** 1. Cryptocephalus sericeus *L.* **B. Diptera.** *Syrphidae*: 2. Syrphus balteatus *Deg.*, po-dvg. **C. Hymenoptera.** 3. Bombus soroënsis *F.*, var. proteus *Gerst.*, skg., ♀ also po-cltg. **D. Lepidoptera.** 4. Pieris sp., skg. Friese (Thuringia), the bee Andrena polita *Sm.* Verhoeff (Norderney), a Scarabaeid beetle (Phyllopertha horticola *L.*, po-dvg.), an Empid (Hilara quadrivittata *Mg.*), and 2 Muscids (Anthomyia sp., and Cyrtoneura hortorum

Fall.). Schmiedeknecht (Thuringia), 2 bees (Andrena fulvago *Chr.* ♀, and A. humilis *Imh.*). Friese in Alsace (A.), Baden (B.), Hungary (H.), and Mecklenburg (M.), 3 bees —1. Andrena fulvago *Chr.* (B., M.), rare; 2. A. humilis *Imh.* (A., B., H. rare, M. more freq.); 3. Nomada alboguttata *H.-Sch.*, rare (H., M.). Loew in Anhalt (A.) and Brandenburg (B.) ('Beiträge,' p. 40), 6 bees—1. Andrena albicans *Müll.* ♀, po-cltg. (A.); 2. A. fulvescens *Sm.* ♂, skg. (A.); 3. A. ventralis *Imh.* ♀ and ♂, do. (A.); 4. Halictus leucozonius *Schr.* ♀, po-cltg. (B.); 5. H. quadricinctus *F.* ♀, po-cltg. (A.); 6. H. sexcinctus *F.* ♀, po-cltg. (B.): (Silesia).—**A. Coleoptera.** *Chrysomelidae*: 1. Cryptocephalus sericeus *L.* **B. Diptera.** (*a*) *Muscidae*: 2. Echinomyia tessellata *F.* (*b*) *Syrphidae*: 3. Chrysotoxum octomaculatum *Curt.*, skg. **C. Hymenoptera.** *Apidae*: 4. Dasypoda hirtipes *F.* ♀, po-cltg.; 5. Panurgus lobatus *F.* ♂ and ♀, ♀ po-cltg.; 6. Prosopis communis *Nyl.* ♂; 7. P. sinuata *Schenck* ♂. **D. Lepidoptera.** *Rhopalocera*: 8. Rhodocera rhamni *L.*, skg. Schletterer for the Tyrol (T.) and Pola (P.), 7 bees—1. Andrena marginata *F.* (=A. cetii *Schr.*); 2. Dufourea vulgaris *Schenck*; 3. Halictoides dentiventris *Nyl.*; 4. Halictus fasciatellus *Schenck* (P.); 5. H. flavipes *F.*; 6. H. longulus *Sm.*; 7. H. minutus *K.* von Dalla Torre (Tyrol), the first 3 of these bees. Loew (Switzerland) ('Beiträge,' p. 59), a beetle (Chrysochus pretiosus *F.*), and 2 bees (Andrena fulvago *Chr.* ♀, po-cltg., and Panurgus banksianus *K.* ♂, skg.). Herm. Müller (Switzerland), a beetle, a butterfly, and 2 short-tongued bees. MacLeod (Pyrenees), 2 species of the bee genus Panurgus, an ant, a Lepidopterid, 6 beetles, a Syrphid, and 6 Muscids (Bot. Jaarb. Dodonaea, Ghent, iii, 1891, pp. 369–70). H. de Vries (Netherlands) (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875), 5 bees—1. Apis mellifica *L.* ☿; 2. Halictus cylindricus *F.* ♀; 3. H. leucozonius *Schr.* ♀; 4. H. villosulus *K.* ♀; 5. Nomada ruficornis *L.* ♀. Smith (England), 6 bees—1. Andrena albicrus *K.*; 2. A. fulvago *Chr.*; 3. A. humilis *Imh.* (=A. fulvescens *Sm.*); 4. Dasypoda plumipes *Pz.*; 5. Epeolus variegatus *L.*; 6. Panurgus calcaratus *Scop.* Saunders (England), the bee Andrena angustior *K.* E. D. Marquard (Cornwall), the bee Andrena fulvescens *Sm.*

1663. **H. Auricula** L.—Linnaeus says that in this species the heads open at Upsala about 8 a.m., and close again about 2 p.m.

VISITORS.—The following were recorded by the observers, and for the localities stated.—

Herm. Müller (Alps), 2 beetles, 3 Muscids, a bee, and 8 Lepidoptera ('Alpenblumen,' pp. 460–1). Loew (Berlin Botanic Garden), a Muscid (Anthomyia sp.).

1664. **H. aurantiacum** L.—Hermann Müller has pointed out ('Alpenblumen,' p. 461) that the orange-red florets of this species, like the similarly coloured ones of Senecio abrotanifolius and Crepis aurea, are visited with zest by red butterflies (*cf.* Vol. I, p. 144). Kerner states that the heads open at Innsbruck about 6–7 a.m., and close again 3–4 p.m.

VISITORS.—Herm. Müller (Alps) observed butterflies (3 sp. of Argynnis, one of Melitaea, and one of Polyommatus), and a hawk-moth (Zygaena sp.).

1665. **H. villosum** Jacq. (Herm. Müller, 'Alpenblumen,' pp. 461–2.)

VISITORS.—Herm. Müller saw 3 Hymenoptera, 2 Lepidoptera, and 3 flies in the Alps.

1666. **H. granduliferum** Hoppe. (Herm. Müller, 'Alpenblumen,' p. 462.)

VISITORS.—Hermann Müller saw 2 flies in the Alps.

1667. **H. albidum** Vill. (=H. intybaceum *Wulf.*).—

VISITORS.—Herm. Müller saw a humble-bee and a Lepidopterid in the Alps (op. cit.).

1668. H. staticifolium Vill. (Herm. Müller, 'Alpenblumen,' p. 461.)—

Visitors.—Herm. Müller saw 13 flies, 7 bees, and 19 Lepidoptera in the Alps. Schletterer records the bee Andrena propinqua *Schenck* for the Tyrol.

1669. H. laevigatum Willd.—

Visitors.—Loew observed the beetle Cryptocephalus sericeus *L.* in Brandenburg ('Beiträge,' p. 40).

1670. H. vulgatum Fries.—

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (Kiel), a hover-fly (Helophilus pendulus *L.*, skg. and po-dvg.), a Muscid (Musca sp.), and a Tortricid moth (Tortrix sp.). Herm. Müller ('Fertilisation,' p. 356, 'Weit. Beob.,' III, p. 93).—**A. Diptera.** *Syrphidae*: 1. Eristalis tenax *L.*, po-dvg. (Bavarian Oberpfalz). **B. Hymenoptera.** *Apidae*: 2. Andrena coitana *K.* ♂, skg.; 3. A. denticulata *K.* ♂, do.; 4. A. fulvescens *Sm.* ♀, po-cltg.; 5. Bombus rajellus *K.* ♀, skg.; 6. B. sylvarum *L.* ♀, do.; 7. B. terrester *L.* ♀, do.; 8. Halictus cylindricus *F.* ♀ and ♂, freq., po-cltg. and skg.; 9. Panurgus calcaratus *Scop.* ♀ and ♂, freq., po-cltg. and skg. **C. Lepidoptera.** *Rhopalocera*: all skg.: 10. Epinephele hyperanthus *L.* (Bavarian Oberpfalz); 11. E. janira *L.* (Bavarian Oberpfalz); 12. Erebia ligea *L.* (Fichtelgebirge); 13. Lycaena icarus *Rott.*; 14. Melitaea athalia *Esp.* (Thuringia). MacLeod (Flanders), a Bombus, 5 short-tongued bees, a Siricid, 14 hover-flies, 6 Muscids, 4 Lepidoptera, and 2 beetles (Bot. Jaarb. Dodonaea, Ghent, v, 1893, pp. 435–7). H. de Vries (Netherlands), the bee Chelostoma florisomne *L.* ♂ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875). Loew (Berlin Botanic Garden), a hover-fly (Eristalis nemorum *L.*) and 2 bees (Megachile centuncularis *L.* ♀, po-cltg., and Osmia fulviventris *Pz.* ♀, do.).

1671. H. murorum L.—Linnaeus states that the heads of this species open at Upsala about 9 a.m., and close again about 1 p.m.

Visitors.—The following were recorded by the observers, and for the localities stated.—

Knuth (Thuringia), a beetle (Cryptocephalus sericeus *L.*), 2 bees (Bombus soroënsis *F.*, var. proteus *Gerst.*, skg., and Halictus punctulatus *K.* ♀, skg. and po-cltg.), and a butterfly (Pieris napi *L.*, skg.) ('Bloemenbiol. Bijdragen'): (Lauterberg in the Harz, 9.10.'97), the hover-fly Eristalis rupium *F.*, po-dvg. Loew (Alps), the short-tongued bee Andrena fulvago *Chr.* ♀, po-cltg. ('Beiträge,' p. 58). Borgstette (Tecklenburg), the bee Andrena listerella *K.* ♀, po-cltg. Buddeberg (Nassau), 2 bees (Halictus albipes *F.* ♂, skg., and H. tetrazonius *Klg.* ♀, do.) (Herm. Müller, 'Weit. Beob.,' p. 93). Alfken (Bremen), 9 bees—1. Andrena denticulata *K.* ♂; 2. Dasypoda plumipes *Pz.* ♀ and ♂; 3. Dufourea halictula *Nyl.* ♀; 4. D. vulgaris *Schenck* ♀ and ♂; 5. Halictus flavipes *F.* ♂; 6. H. leucozonius *Schr.* ♂; 7. Panurgus banksianus *K.* ♀ and ♂; 8. P. calcaratus *Scop.* ♀ and ♂; 9. Prosopis communis *Nyl.* ♀. Schletterer (Tyrol), the humble-bee Bombus soroënsis *F.* Loew (Berlin Botanic Garden), 2 bees (Coelioxys rufescens *Lep.* ♀, skg., and Osmia fulviventris *Pz.* ♀, po-cltg.).

1672. H. umbellatum L. (Herm. Müller, 'Fertilisation,' pp. 354–5, 'Weit. Beob.,' III, p. 92; Knuth, 'Bl. u. Insekt. a. d. nordfr. Ins.,' pp. 98, 163; Verhoeff, 'Bl. u. Insekt. a. d. Ins. Norderney'; de Vries, Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875.)—The expanded heads of this species are 25 mm. in diameter. Hermann Müller says that the golden-yellow florets possess corolla-

tubes 3–5 mm. and ligules 8–16 mm. long. The style grows through the anther-cylinder, sweeping before it the pollen which adheres to its spinose sweeping-hairs, for 6 mm., 2½ mm. of this being taken up by its branches. In the second stage of anthesis these branches gradually diverge and bend back until the stigmatic papillae touch the pollen clinging to the sweeping-hairs, so that automatic self-pollination must take place if insect-visits fail.

Linnaeus says that the heads open at Upsala about 6 a.m., and close again about 5 p.m.

VISITORS.— Herm. Müller gives the following list for Lippstadt.—

A. Coleoptera. 1. Coccinella quinquepunctata *L.* **B. Diptera.** (*a*) *Conopidae*: 2. Occemyia atra *F.*, skg.; 3. Sicus ferrugineus *L.*, do. (*b*) *Syrphidae*: 4. Eristalis arbustorum *L.*, very common, po-dvg. and skg.; 5. E. nemorum *L.*, skg.; 6. E. tenax *L.*, very common, po-dvg. and skg.; 7. Syrphus balteatus *Deg.*, do.; 8. S. ribesii *L.*, po-dvg. **C. Hymenoptera.** (*a*) *Apidae*: 9. Apis mellifica *L.* ☿, freq., skg. and po-cltg.; 10. Bombus lapidarius *L.* ☿, skg.; 11. Coelioxys conoidea *Ill.* ♀, do.; 12. C. simplex *Nyl.* ♀, do.; 13. Dasypoda hirtipes *F.* ♀, skg. and po-cltg.; 14. Halictus cylindricus *F.* ♂, skg.; 15. H. leucozonius *Schr.* ♀ and ♂, po-cltg. and skg.; 16. H. villosulus *K.* ♀ and ♂, do.; 17. H. zonulus *Sm.* ♀; 18. Megachile argentata *F.* ♀, skg.; 19. M. willughbiella *K.* ♂, do.; 20. Panurgus calcaratus *Scop.* ♀ and ♂, po-cltg. and skg.; 21. Sphecodes gibbus *L.* ♂, skg. (*b*) *Chrysididae*: 22. Hedychrum lucidulum *F.* ♂. **D. Lepidoptera.** *Rhopalocera*: all skg.: 23. Hesperia sp.; 24. Lycaena icarus *Rott.*; 25. Pieris napi *L.*, freq.; 26. P. rapae *L.*; 27. Polyommatus dorilis *Hfn.*; 28. Pararge megaera *L.*, do.; 29. Vanessa urticae *L.*, not infrequent.

FIG. 210. *Hieracium umbellatum*, *L.* (after Herm. Müller). (1) Floret in the second stage (× 7). (2) The stylar branches, still further recurved, so that autogamy is ultimately possible. (3) The part *ab* of the left stylar branch of (1) (× 60). (4) Floret in which self-pollination is taking place (× 7). *c*, stigmatic papillae; *d*, sweeping-hairs; *e*, pollen-grains; *f*, anther-cylinder; *g*, filaments; *h*, style; *i*, corolla-tube; *k*, unsymmetrical limb of the corolla; *l*, pappus; *m*, ovary.

Alfken observed the following.—

In Juist.—**A. Diptera.** (*a*) *Muscidae*: 1. Cynomyia mortuorum *L.*; 2. Echinomyia tessellata *L.*; 3. Lucilia caesar *L.* (*b*) *Syrphidae*: 4. Eristalis tenax *L.*; 5. Melithreptus sp.; 6. Platycheirus manicatus *Mg.* **B. Hymenoptera.** *Apidae*: 7. Bombus distinguendus *Mor.*; 8. B. hortorum *L.* ♂; 9. B. lapidarius *L.* ☿ and ♂; 10. B. muscorum *F.* ☿ and ♂; 11. B. terrester *L.* ♂; 12. Dasypoda plumipes *Pz.* ♀,

very common, often 3 or 4 in a head, skg. and po-cltg., ♂ skg. (*b*) *Sphegidae*: 13. Ammophila sabulosa *L.*; 14. Oxybelus mucronatus *F.* **C. Lepidoptera.** (*a*) *Lycaenidae*: 15. Lycaena icarus *Rott.*; 16. Polyommatus phlaeas *L.* (*b*) *Pieridae*: 17. Pieris brassicae *L.*; 18. P. napi *L.* (*c*) *Satyridae*: 19. Epinephele janira *L.* In Bremen, 9 bees—1. Andrena gwynana *K.* ♂, 2nd gen.; 2. A. humilis *Imh.* ♀; 3. Bombus distinguendus *Mor.* ☿; 4. B. hortorum *L.* ☿; 5. B. muscorum *F.* ☿; 6. Dasypoda plumipes *Pz.* ♀ and ♂; 7. Melitta leporina *Pz.* ♂; 8. Panurgus banksianus *K.* ♀ and ♂; 9. P. calcaratus *Scop.* ♀ and ♂.

Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis aeneus *Scop.*; 2. E. arbustorum *L.*; 3. E. nemorum *L.*; 4. E. tenax *L.*; 5. Helophilus floreus *L.*; 6. Syritta pipiens *L.*; 7. Syrphus albostriatus *Fall.* **B. Hymenoptera.** (*a*) *Apidae*: 8. Apis mellifica *L.* ☿, skg. and po-cltg.; 9. Dasypoda hirtipes *F.* ♂, do.; 10. Halictus leucozonius *Schr.* ♀ and ♂, skg. (*b*) *Sphegidae*: 11. Ammophila sabulosa *L.* **C. Lepidoptera.** *Rhopalocera*: all skg.; 12. Rhodocera rhamni *L.*; 13. Pieris brassicae *L.*; 14. P. rapae *L.*

The following were recorded by the observers, and for the localities stated.—

Knuth (North Frisian Islands), Apis, a Bombus, a Panurgus, a hover-fly, and a butterfly. Verhoeff (Norderney).—**A. Diptera.** *Syrphidae*: 1. Eristalis arbustorum *L.* ♂, freq.; 2. Syrphus corollae *F.* ♂, do.; 3. S. nitidicollis *Mg.* ♀, occasional. **B. Hymenoptera.** *Apidae*: 4. Bombus lapidarius *L.* ☿ and ♂, freq.; 5. B. terrester *L.* ☿; 6. Psithyrus rupestris *F.* ♂. **C. Lepidoptera.** *Nymphalidae*: 7. Argynnis latonia *L.*, occasional. H. de Vries (Netherlands), the humble-bee Bombus subterraneus *L.* ☿ (Ned. Kruidk. Arch., Nijmegen, 2. Ser., 2. Deel, 1875).

1673. **H. australe** Fries.—

Visitors.—Loew (Berlin Botanic Garden) observed 3 bees—1. Apis mellifica *L.* ☿, skg. and po-cltg.; 2. Bombus agrorum *F.* ♂, skg.; 3. Halictus leucozonius *Schr.* ♀, do.

1674. **H. boreale** Fries.—

Visitors.—Loew observed the bee Prosopis armillata *Nyl.* ♀, skg., in the Berlin Botanic Garden.

1675. **H. brevifolium** Tausch.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. (*a*) *Muscidae*: 1. Anthomyia sp. (*b*) *Syrphidae*: 2. Helophilus floreus *L.* **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.; 4. Bombus terrester *L.* ♀, skg.; 5. Halictus cylindricus *F.* ♂, do.; 6. Halictus nitidiusculus *K.* ♂, do.; 7. Panurgus calcaratus *Scop.* ♀.

1676. **H. bupleuroides** Gmel.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis tenax *L.*; 2. Helophilus pendulus *L.* **B. Hymenoptera.** *Apidae*: 3. Apis mellifica *L.* ☿, skg. and po-cltg.; 4. Heriades truncorum *L.* ♂, skg.; 5. Prosopis sp. ♀, do.

1677. **H. crinitum** Sibth. et Sm.—

Visitors.—Loew observed the following in the Berlin Botanic Garden.—

A. Diptera. *Syrphidae*: 1. Eristalis nemorum *L.*; 2. E. tenax *L.*; 3. Helophilus floreus *L.*; 4. Syritta pipiens *L.* **B. Hymenoptera.** *Apidae*: 5. Apis mellifica *L.* ☿, skg. and po-cltg.; 6. Halictus cylindricus *F.* ♂, skg.; 7. H. leucozonius *Schr.* ♀, do.

1678. H. cymosum L.—

VISITORS.—Loew observed the hover-fly Syrphus balteatus *Deg.* in the Berlin Botanic Garden.

1679. H. echioides Lumnitz.—

VISITORS.—Loew observed the bee Osmia fulviventris *Pz.* ♀, po-cltg., in the Berlin Botanic Garden.

1680. H. foliosum Waldst. et Kit.—

VISITORS.—Loew observed a hover-fly (Pipiza festiva *Mg.*) and a bee (Chelostoma campanularum *K.* ♀, po-cltg.) in the Berlin Botanic Garden.

1681. H. hirsutum Bernh.—

VISITORS.—Loew observed a hover-fly (Syritta pipiens *L.*), a bee (Psithyrus vestalis *Fourcr.* ♂, skg.), and a butterfly (Vanessa io *L.*, skg.) in the Berlin Botanic Garden.

1682. H. porphyritae F. W. Schultz.—

VISITORS.—Loew observed the bee Stelis aterrima *Pz.* ♀, skg., in the Berlin Botanic Garden.

1683. H. pratense Tausch.—

VISITORS.—Loew observed the hover-fly Syrphus balteatus *Deg.* in the Berlin Botanic Garden.

1684. H. pulmonarioides Vill.—

VISITORS.—Loew observed the bee Apis mellifica *L.* ☿, skg. and po-cltg., in the Berlin Botanic Garden.

1685. H. Retzii Griseb.—

VISITORS.—Loew observed the bee Osmia fulviventris *Pz.* ♀, po-cltg., in the Berlin Botanic Garden.

1686. H. virosum Pall.—

VISITORS.—Loew observed a hover-fly (Eristalis tenax *L.*) and 3 bees (1. Apis mellifica *L.* ☿, skg. and po-cltg.; 2. Halictus cylindricus *F.* ♂, skg.; 3. H. nitidiusculus *K.* ♀, skg.) in the Berlin Botanic Garden.

LVI. ORDER *STYLIDIEAE* R. Br.

Delpino ('Ult. oss.,' pp. 125–6) examined herbarium specimens of species belonging to this order, and describes them as markedly protandrous, so that they are apparently adapted to insect-visits.

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